I apologize for the spraeling messiness of this packet. It is a combination of 1) things to know 2) unsolved problems 3) solved problems. It is a broad survey meant to be a starting point that jogs your memory.

Review for the June 2014 Chemistry Final Exam

(The exam covers only second semester, from Jan 27 to June 6th)

Disclaimer: Studying this packet is a great start but is not a substitute for actually studying all 80 days of material. Hopefully time spent with this packet will help you find what parts of the semester you need to go back and study in depth, either from your notes or from http://genest.weebly.com

Of the 80 days we have been together this semester, the things in this packet are the ones that came up over and over.

About a third of what you need to know are specific facts. Get these from your notes.

Two thirds of what you need to know are skills. Get these by doing, redoing, and redoing one more time, all of the old homework problems that you learned to solve this semester.

UNIT 9 JOULES, HEAT CAPACITY, STANDARD HEAT OF FORMATION

VOCABULARY

a. Calorie
b. Calorimeter
c. Calorimetry
d. Chemical potential energy
e. Endothermic process
f. Energy
g. Enthalpy
h. Exothermic process
i. Heat
j. Heat capacity
k. Heat of combustion
l. Heat of reaction
m. Joule
n. Law of conservation of energy
o. Specific heat
p. Standard heat of formation
q. Surroundings
r. System

FORMULAS

a. Thermochemical equation
    i. A + B -> C + 44J
    ii. A + B -> C $\Delta H = -44J$

b. 1 Calorie = 1000 calories = 1 kcal
c. 1 J = 1 cal
d. $q = m\, c\, \Delta T$

Recall: 4.184 joules = 1.000 calorie 1000 J = 1 kJ

1. Touching a test tube that contains an endothermic reaction your hand will feel (hot / cold) We would describe the change to your hand as
   (exothermic / endothermic).

2. The system is underlined. For <u>a pile of paper</u> that is set on fire,
   a. ΔH = zero
   b. ΔH = a positive number
   c. ΔH = a negative number
3. If you combine two solutions in a test tube and the test tube feels hot to your hand, the reaction was definitely
   a. endothermic
   b. exothermic
4. Which represents the smallest amount of energy:
   a. 1 calorie
   b. 1 Calorie
   c. 1 joule

5. If a hot lump of iron is dropped into maple syrup, complete the following description by writing the word HEAT into only one of the blank spaces. Leave the other space blank.

cold syrup + ______ -> hot syrup + _______

6. Calculate the number of joules that would be given off by burning 10.0 grams of ammonia. Assume that burning 2.5 grams of ammonia gas gives off 820 calories of heat.

7. Convert 5.051 calories to kilojoules. Show work:

8. When 2 moles of solid calcium combines with 1 mole of fluorine gas, 2 mol of solid calcium fluoride (CaF2) is formed and 843 kJ of heat is released. Write the thermochemical equation for this combustion reaction.

9. Indicate whether each item describes potential or kinetic energy:
   a. The energy in a cell phone battery

   ____

   b. A daredevil skiing backwards over a jump

____

10. Which of these can be detected by the senses or by instruments? (circle only one choice)
    a. both heat and temperature
    b. temperature only
    c. heat only
    d. neither heat nor temperature

11. Which pattern is true for heat capacity of materials?
    a. the heat capacities (the “C”) of metals and water are about equal
    b. water has a heat capacity much higher than metals
    c. water has a heat capacity much lower than metals

12. A burning match releases 330. calories. Calculate the energy released by 5 matches in calories

13. In the formula Q = (m)(C)(ΔT) tell one unit that could be used to measure each variable.
    a. a unit for ΔT could be _________________
    b. a unit for C could be _________________
    c. a unit for Q could be _________________

a unit for m could be _________________

Name ANSWERS Ω

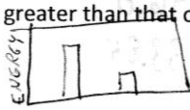
1. Formation of $Al_2O_{3(s)}$ from its elements in their standard states. (see page 316)
   ΔH = −1676.0 kJ/mol
2. Write just the reaction that describes forming each compound from its elements in their standard states:
   a. $H_2O_{(L)}$ $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(L)}$
   b. $CaCO_{3(s)}$ (the standard state of metals is a single atom, solid. For carbon, a single atom, solid)
   $2Ca_{(s)} + 2C_{(s,\,graphite)} + 3O_{2(g)} \rightarrow 2CaCO_3$
3. Indicate whether each item describes potential or kinetic energy:
   a. Water at the top of a waterfall POTENTIAL ENERGY
   b. Kicking a ball KINETIC ENERGY
   c. The energy in a lump of coal POTENTIAL ENERGY
   d. A skier at the top of a hill POTENTIAL ENE
4. Indicate whether each item describes potential or kinetic energy:
   a. The energy in your food Potential
   b. A tightly wound spring Potential
   c. An earthquake Kinetic
   d. A car speeding down the freeway Kinetic

Units of Energy Conversions

5. A burning match releases 1100 J. Convert the energy released by 20 matches to the following energy units:
   a. Kilojoules $20\text{ matches} \times \left(\frac{1100\ J}{1\ \text{matches}}\right)\left(\frac{1\ kJ}{1000\ J}\right) = 22\ kJ$
   b. Calories $20\text{ matches} \times \left(\frac{1100\ J}{1\ \text{match}}\right)\left(\frac{1\ cal}{4.184\ J}\right) \times \left(\frac{1\ Cal}{1000\ cal}\right) = 5.3\ Ca$

Energy in Chemical Reactions

6. In exothermic reactions, is the energy of the products less or greater than that of the reactants?
   reactants → products
   (more energy) (less energy)



7. Classify the following as exothermic or endothermic:
   a. 550 kJ is released EXOTHERMIC
   b. The energy level of the products is higher than that of the reactants. ENDOTHERMIC
   c. The metabolism of glucose in the body provides energy. EXOTHERMIC
   d. The energy level of the products is lower than that of the reactants. EXOTHERMIC
   e. 125 kJ is absorbed. ENDOTHERMIC

8. Classify the following as exothermic or endothermic reaction and give ΔH for each:
   a. Gas burning in a Bunsen burner: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 890$ kJ EXOTHERMIC
   b. Dehydrating limestone: $Ca(OH)_2 + 65.3$ kJ $\rightarrow CaO + H_2O$ ENDOTHERMIC
   c. Formation of aluminum oxide and iron from aluminum and iron(III)oxide: Exothermic
   d. $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe + 850$ kJ
   e. Combustion of propane: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + 2200$ kJ EXOTHERMIC
   f. Formation of table salt: $2Na + Cl_2 \rightarrow 2NaCl + 2H_2O + 819$ kJ EXOTHERMIC
   g. Decomposition of phosphorous pentachloride: $PCl_5 + 67$ kJ $\rightarrow PCl_3 + Cl_2$ ENDOTHERMIC

9. In an endothermic reaction, is the energy of the products less than or greater than that of the reactants? greater

10. The equation for the formation of silicon tetrachloride from silicon and chlorine is
    $Si + 2Cl_2 \rightarrow SiCl_4$ $\Delta H = -657$ kJ
    How many kilojoules are released when 125 g of Cl_2 reacts with silicon?
    $125 g\ Cl_2 \times \left(\frac{1\ mol\ Cl_2}{70.90\ g\ Cl_2}\right) \times \left(\frac{-657\ kJ}{2\ mol\ Cl_2}\right) = 579\ kJ$

Heat of formation

Using the table on p. 316 of your textbook write just the ΔH term for each .

11. Formation of $Fe_2O_{3(s)}$ from its elements in their standard states.
    ΔH = **- 822.1 kJ/mol**

12. Formation of $Br_{2(L)}$ from its elements in their standard states.
    ΔH = **0**

13. Write just the reaction that describes forming each compound from its elements in their standard states:
    a. $H_2O_{(L)}$ $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(L)}$

    b. $H_2O_{(g)}$ $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

14. Now put together your skills from the previous two questions. For each substance, write the ΔH term for each **and** the reaction that describes forming each compound from its elements in their standard states (p. 316 has a helpful table).
    a. $SO_{2(g)}$
       ΔH = **-296.8 kJ/mol** reaction: $S_{8(s)} + 8O_{2(g)} \rightarrow 8SO_2$
    b. $NO_{2(g)}$
       ΔH = **+33.85** reaction: $N_{2(g)} + 2O_{2(g)} \rightarrow 2NO_{2(g)}$
    c. $Fe_2O_{3(s)}$
       ΔH = - 822.1 reaction: $4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$
    d. $N_{2(g)}$
       ΔH = 0 reaction: $N_{2(g)} \rightarrow N_{2(g)}$

Table 11.4

Heats of Combustion at 25 °C		
Substance	**Formula**	**ΔH (kJ/mol)**
Hydrogen	$H_2(g)$	−286
Carbon	$C(s)$, graphite	−394
Carbon monoxide	$CO(g)$	−283
Methane	$CH_4(g)$	−890
Methanol	$CH_3OH(l)$	−726
Acetylene	$C_2H_2(g)$	−1300
Ethanol	$C_2H_5OH(l)$	−1368
Propane	$C_3H_8(g)$	−2220
Benzene	$C_6H_6(l)$	−3268
Glucose	$C_6H_{12}O_6(s)$	−2808
Octane	$C_8H_{18}(l)$	−5471
Sucrose	$C_{12}H_{22}O_{11}(s)$	−5645

Table 11.5

Heats of Physical Change					
Substance	**Formula**	**Freezing point (K)**	**ΔH_{fus} (kJ/mol)**	**Boiling point (K)**	**ΔH_{vap} (kJ/mol)**
Acetone	CH_3COCH_3	177.8	5.72	329.4	29.1
Ammonia	NH_3	195.3	5.65	239.7	23.4
Argon	Ar	83.8	1.2	87.3	6.5
Benzene	C_6H_6	278.7	9.87	353.3	30.8
Ethanol	C_2H_5OH	158.7	4.60	351.5	43.5
Helium	He	3.5	0.02	4.22	0.08
Hydrogen	H_2	14.0	0.12	20.3	0.90
Methane	CH_4	90.7	0.94	111.7	8.2
Methanol	CH_3OH	175.5	3.16	337.2	35.3
Neon	Ne	24.5	0.33	27.1	1.76
Nitrogen	N_2	63.3	0.72	77.4	5.58
Oxygen	O_2	54.8	0.44	90.2	6.82
Water	H_2O	273.2	6.01	373.2	40.7

Table 11.6

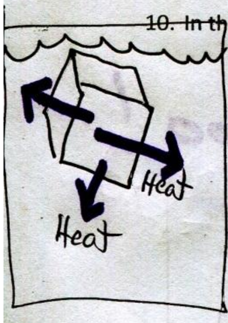
Standard Heats of Formation (ΔH_f^0) at 25 °C and 101.3 kPa					
Substance	**ΔH_f^0 (kJ/mol)**	**Substance**	**ΔH_f^0 (kJ/mol)**	**Substance**	**ΔH_f^0 (kJ/mol)**
$Al_2O_3(s)$	−1676.0	$Fe(s)$	0.0	$NO(g)$	90.37
$Br_2(g)$	30.91	$Fe_2O_3(s)$	−822.1	$NO_2(g)$	33.85
$Br_2(l)$	0.0	$H_2(g)$	0.0	$Na_2CO_3(s)$	−1131.1
$C(s$, diamond)	1.9	$H_2O(g)$	−241.8	$NaCl(s)$	−411.2
$C(s$, graphite)	0.0	$H_2O(l)$	−285.8	$O_2(g)$	0.0
$CH_4(g)$	−74.86	$H_2O_2(l)$	−187.8	$O_3(g)$	142.0
$CO(g)$	−110.5	$HCl(g)$	−92.31	$P(s$, white)	0.0
$CO_2(g)$	−393.5	$H_2S(g)$	−20.1	$P(s$, red)	−18.4
$CaCO_3(s)$	−1207.0	$I_2(g)$	62.4	$S(s$, rhombic)	0.0
$CaO(s)$	−635.1	$I_2(s)$	0.0	$S(s$, monoclinic)	0.30
$Cl_2(g)$	0.0	$N_2(g)$	0.0	$SO_2(g)$	−296.8
$F_2(g)$	0.0	$NH_3(g)$	−46.19	$SO_3(g)$	−395.7

8. Convert 1365 calories to Calories

$$1365 \text{ calories} \times \frac{1 \text{ Calorie}}{1000 \text{ calories}} = 1.365 \text{ Calories}$$

9. Touching a test tube that has a reaction that contains an exothermic reaction your hand will feel (hot / cold) because heat will flow towards (your hand / the test tube reaction). If your hand is considered the system, the change is therefore (exothermic / endothermic). ← note!

10. In the box sketch a hot metal cube that has just been dropped into a glass of water.



a. In your cartoon draw an arrow to show where heat is flowing.
b. If the water is the system this change was (exothermic / endothermic)
c. If the metal is the system this change was (exothermic / endothermic)
d. Write + or – in the parentheses to show whether you would expect a positive or negative number in the heat equation ← answer

water before → water after $\Delta H = (+)$

e. For the change described above, the energy flow can also be described with the words shown below -- except someone accidentally wrote the word *heat* twice. Cross off the one that does not belong.

water + heat → water after + heat

11. The change in the previous problem could also be considered from the point of view of the metal.

a. Write + or – in the parentheses to show whether you would expect a positive or negative number in the heat equation ← answer

metal before → metal after $\Delta H = (-)$

b. For the change described above, the energy flow can also be described with the words shown below -- except someone accidentally wrote the word *heat* twice. Cross off the one that does not belong.

metal + heat → metal after + heat

12. How much heat is released when 4.9 moles of methane gas are burned in a constant pressure system? (890. kJ are given off if 1 mole of methane is burned)

$$4.9 \text{ moles} \times \frac{890 \text{ kJ}}{1 \text{ mole}} = 4361 \approx 4400 \text{ kJ}$$

13. In an experiment, liquid heptane, C_7H_{16} (l), is completely combusted to produce CO_2 (g) and H_2O (l), as represented by the following equation.

$$C_7H_{16}(l) + 11O_2(g) \rightarrow 7\,CO_2(g) + 8H_2O(l)$$

The heat of combustion, $\Delta H°_{comb}$, for one mole of C_7H_{16}(l) is -4.85×10^3 kJ. Calculate how much heat would be released if 3.11×10^{-4} moles of heptane were combusted

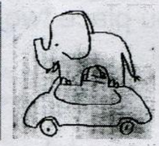
$$3.11 \times 10^{-4} \text{ mol} \times \frac{4.85 \times 10^3 \text{ kJ}}{1 \text{ mole}} = 1.50835 \approx 1.51 \text{ kJ}$$

heat units during temperature changes

ChEMis+ry: http://genest.weebly.com

Stop in for help every day at lunch and Tues, Weds., &Thurs after school!

After-hours question? Email me at home: eagenest@madison.k12.wi.us



Name KEY

Period

1. Using your algebra skills rearrange Q = (m) (C) (ΔT) to isolate the indicated variable in each case (isolate means 'get it on one side of the equals sign by itself).

Isolate C	Isolate ΔT
$Q = mc\Delta T$ rearranges to $\frac{Q}{m\Delta T} = C$	$Q = mc\Delta T$ rearranges to $\frac{Q}{mc} = \Delta T$

2. How much heat is absorbed by 20g granite boulder as energy from the sun causes its temperature to change from 10°C to 29°C? (Specific heat capacity of granite is 0.1 cal/g°C)

$q = (20g)(0.1 \frac{cal}{g°c})(19°c)$

$q = 38 \approx 40$ calories

3. How much heat is released when 30 g of water at 96°C cools to 25°C? The specific heat of water is 1 cal/g°C

$q = (30g)(1 \frac{cal}{g°c})(-71°c)$

$q =$

4. Applying the physicist's definition of the term heat, decide whether or not there is any heat occurring to the object in italics. For each object you should indicate whether the heat is negative, zero or positive.

a) An *ice cube* is placed in a cup of hot coffee POSITIVE
b) A pot of *hot tea* is sealed into a well-insulated thermos ZERO
c) Some cold cream is poured into a cup of *hot coffee* NEGATIVE
d) You blow *air* across a bowl of hot soup POSITIVE
e) *You* jump into an ice cold pond NEGATIVE

5. How much heat will raise a pot of 800 g of water from 20 °C to 90 °C?

$q = (800g)(1 \frac{cal}{g°c})(+70°c)$

$q = 56000$ calories

6. What happens when you place two objects at different temperatures in contact with each other?

Heat Flows from the hot object to the cold until they are equal temper

7. If a 3.1g ring is heated using 10.0 calories, its temperature rises 17.9°C. Calculate the specific heat capacity of the ring.

$q = m C \Delta T$ rearranges to $\frac{q}{m \Delta T} = C$ $\frac{(10.0 cal)}{(3.1g)(17.9°C)} = C$

ANSWER:

8. The temperature of a sample of water increases from 20°C to 46.6°C as it absorbs 5650 calories of heat. What is the mass of the sample? (Specific heat of water is 1.0 cal/g °C)

$\frac{q}{C \Delta T} = m$ $\frac{5650 cal}{(1.0 \frac{cal}{g°C})(26.6°C)} = m$ 210 = grams

9. The temperature of a sample of iron with a mass of 10.0 g changed from 50.4°C to 25.0°C with the release of 47 calories of heat. What is the specific heat of iron?

$\frac{q}{m \Delta T} = C$ $\frac{47 calories}{(10.0g)(-25.4°C)} = C$ $0.19 \frac{cal}{g°C}$ =

10. A 4.50 g coin of copper absorbed 54 calories of heat. What was the final temperature of the copper if the initial temperature was 25°C? The specific heat of copper is 0.092 cal/g°C. (1) FIND ΔT (2) THEN FIND FINAL temp

$\Delta T = \frac{q}{m c}$

$\Delta T = \frac{54 cal}{(4.50g)(0.092 cal/g°C)}$ $\Delta T = 130°C$

$\Delta T = T_f - T_i$

$\Delta T + T_i = T_f$

$(130) + (25) = T_f$

11. A 155 g sample of an unknown substance was heated from 25°C to 40°C. In the process, the substance absorbed 569 calories of energy. What is the specific heat of the substance?

$C = \frac{Q}{m \Delta T}$ $C = \frac{569 cal}{(155g)(+15°C)}$ $C = 0.24 \frac{calories}{g °C}$

12. What is the specific heat of an unknown substance if a 2.50 g sample releases 12 calories as its temperature changes from 25°C to 20°C?

$C = \frac{Q}{m \Delta T}$ $C = \frac{12 calories}{(2.5g)(-5°C)}$ $C = 0.96 \frac{cal}{g°C}$