Thermodynamics Worksheet #1
SCH 4U

1. Steam at 150 °C is slowly cooled to ice to −20 °C. Sketch a heating/cooling curve for this process (vertical axis is temperature, horizontal is heat). If 35 g of ice forms, calculate the total heat involved (note that this is a six step problem). Use specific heat capacities tabulated on page 799 and latent heats found on page 307 for your calculations. After you have completed this, make an accurate graph of temperature versus heat released for this problem.

2. 25 g of gold heated to 800 °C is placed in 200 mL of H_2O at 10 °C. Determine the final temperature of both gold and water after thermal equalization has occurred.

3. Determine how many grams of steam are formed if 120 kcal of heat is added to 0.750 L of water at an initial temperature of 15 °C.

4. 32 g of an unidentified metal is placed in 500 mL of water. The initial temperature of the metal was 100.00 °C and the initial temperature of the water was 20.00 °C. After thermal equilibrium is reached, both the metal and the water are at 20.468 °C Find the specific heat capacity of the metal and identify the metal from the list on page 799.

5. Show a heating curve for the conversion of 355 g of ice at −25 °C to steam at 250 °C. Calculate the total amount of energy required do this by first calculating
   1. heat ice @ −25 °C to ice @ 0 °C
   2. ice @ 0 °C to water @ 0 °C
   3. water @ 0 °C to water @ 100 °C
   4. water @ 100 °C to steam @ 100 °C
   5. steam @ 100 °C to steam @ 250 °C

   The following data should be of assistance:

   Molar Heat of Fusion (melting) of Ice: 6.02 kJ/mol @ 0 °C
   Molar Heat of Vaporization of water: 40.6 kJ/mol @ 100 °C
   Specific Heat Capacity of Ice: 2.033 J/g°C
   Specific Heat Capacity of Water: 4.184 J/g°C
   Specific Heat Capacity of Steam: 2.010 J/g°C

Thermodynamics Worksheet #2
SCH 4U1

1. If the combustion of 13.50g of octane (C_8H_{18}) can warm 10.0 L of water from 20.00 °C to 35.447 °C, calculate the heat of combustion for octane.

2. Determine the volume of water that can be warmed from 25.00 °C to 27.50 °C by the combustion of 12.5 kg of butane (C_4H_{10}) if the heat of combustion of butane is −2877.40 kJ.

3. Given that the heat of combustion of ethyl alcohol (C_2H_5OH) is −1409.2 kJ/mol, determine the change in temperature of 4 L of water that has been warmed by the combustion of 5.00 g of ethyl alcohol.

4. Using heats of formation found on page 799 of your text, determine the heat of combustion for pentane ($C_5H_{12}(l)$). Once you have found this, determine the final temperature of 80.0 L of water at 25.000 °C if 50.0 g of pentane is combusted.

5. 50.0 L of water is warmed by the combustion of 40.0 g of heptane ($C_7H_{16}(l)$) from an intial temperature of 22.000 °C to a final temperature of 31.187 °C. Use this information to determine the heat of combustion for heptane. Once you have completed this, use the heat summation method to determine the heat of formation for heptane.

THE ENTHALPY GAME!!

Label each situation that represents a increase in enthalpy with endo and each situation that represents a decrease in enthalpy with exo.

1. Change of state from a liquid to a solid

2. An increase in chemical potential energy

3. Formation of CO_2 from its elements

4. mixing ammonium nitrate with water lowers the temperature of the water

5. in a reaction atoms rearrange their position to increase the net attraction for other atoms

6. $\Delta H^\circ = -185$ kJ/mol

7. $2H_2O \rightarrow 2H_2 + O_2$

8. an overall increase in bond energy (energy required to overcome a bond)

9. $\Delta H^\circ = 98$ kJ/mol

10. free moving atoms combine to form a compound spontaneously

11. change of state from a liquid to a gas

12. exothermic reaction

13. in a closed system (energy can neither enter nor escape) kinetic energy increases

14. $H_2O(l) + 10.5$ kcal $\rightarrow H_2O(g)$

15. in a reaction net attraction between atoms is lessened

16. $CH_4 + {}^3/_2O_2 \rightarrow CO_2 + H_2O$

17. endothermic reaction

18. a rock falls off a cliff

19. in a closed system potential energy increases

20. mixing NaOH(s) with water produces heat

21. The assembly of a lattice from free ions

22. The hydration of ions in solution

23. A dissolving process inwhich the hydration energy is greater than the lattice energy (the interaction between solvent and solute is stronger than the interaction within the lattice structure)

24. $CO + Cl_2 \rightarrow COCl_2$

25. The ionization of magnesium to form Mg^{2+} ($Mg \Longrightarrow Mg^{2+} + 2e^-$)

26. The vapourization of NaCl(s) to form free Na^{1+} ions and free Cl^{1-} ions (i.e. breaking the lattice energy).

27. The formation of a solution of a salt from water and the solid of the salt.

Summary: In the chart list as many different ways that you can determine if enthalpy has increased and list the counter statement for the decrease in enthalpy.

INCREASE IN ENTHALPY (ENDOTHERMIC)	**DECREASE IN ENTHALPY (EXOTHERMIC)**

COMBINATION PROBLEMS
SCH 4U – THERMODYNAMICS

1. 30 L of water in a bomb calorimeter is warmed from 20.00 °C to 23.94 °C when 10 g of butane (C_4H_{10}) is reacted with sufficient oxygen to allow complete combustion. Use this information plus appropriate heats of formation (i.e. values for carbon dioxide, water and oxygen) to derive the heat of formation for the compound butane. Check this answer with the heat of formation value for butane found in the table to see if the information in the question is correct.

5

2. Determine the change in temperature in 50.00 L of water when warmed by the combustion of 25.00 g of butane, $C_4H_{10}(g)$.

2

3. Determine the heat of formation of hexane given that the combustion of 15.0 g of hexane (C_6H_{14}) can warm 25.000 l of water from 25.000 °C to 31.925 °C. DO NOT USE THE TABLES IN THE BOOK FOR THIS QUESTION (except to check your answer)!!! Note that this is a multi-step problem – use appropriate format.

1

4. From the following information, calculate $\Delta H_{H_3PO_4(aq)}$ in kJ

a) $\Delta H_{H_2O(l)}$ = −285.77 kJ

7 b) $\Delta H_{P_4O_{10}(s)}$ = −3012.48 kJ

c) The natural form of phosphorus is P(s).

d) 13.5 g of $P_4O_{10}(s)$ is placed in exactly 1 L of water and an exothermic reaction proceeds inwhich $H_3PO_4(aq)$ is the only product. The temperature is observed to increase from 15.03 °C to 19.93°C

e) The specific heat capacity of water is 4.184 J/g°C.

f) The answer is $\Delta H_{H_3PO_4(aq)}$ = −308.2 kcal

5. Calculate the mass of benzene liquid ($C_6H_6(l)$) that can provide 100 kJ of heat through a combustion reaction. Use the table in your text. No need to use Hess' Law.

3

6. Determine the mass of propane that must be combusted to warm 160 L of water from 15 °C to 52 °C. You may use any heats of formation from the textbook that you like.

9

7. If 50 L of water is warmed by 11.469 °C by the combustion of 50 g of decane ($C_{10}H_{22}(l)$), determine the heat of formation of decane. This is not a Hess' Law problem. You may use any heats of formation that you wish from the textbook.

9

8. The combustion of 21.9 g of ethanol C_2H_5OH is able to warm 8.000 L of water from 20 °C to 40 °C, determine the heat of formation of ethanol. Do not use Hess' Law in your solution.

8

12

9. Determine the volume of water in L that can be warmed from 15 °C to 70 °C, by the combustion of 500 g of cyclopropane.

10

10. When 10 g of butane (C_4H_{10}) is reacted with sufficient oxygen to allow complete combustion 30 L of water in a bomb calorimeter is warmed from 20.00 °C to 23.94 °C. Use this information plus appropriate heats of formation (i.e. values for carbon dioxide, water and oxygen) to derive the heat of formation for the compound butane. Check this answer with the heat of formation value for butane found in the table in your text to see if the information in this question is correct. Please perform your calculation in kJ. Do not use Hess' Law.

11

11. Determine the mass of water at 25 °C that can be converted to water at 100 °C by the combustion of 800 g of propane. At no point use Hess' Law in this determination. (For a bonus, determine what the mass of water would be if it were converted to steam at 100 °C instead of water at 100 °C)

11

12. From the following data and the eventual use of Hess' Law, determine the heat of formation of calcium oxide (CaO). Note, both reactions were performed in 100 mL of 1.0 M HCl, which can be considered to be the same as water (i.e. specific heat capacity is 4.184 J /g°C Hummm! This looks a lot like one of your lab calculations!

Equation	Initial Temp. °C	Final Temp. °C	Masses etc.
$Ca(s) + 2HCl(aq) \Rightarrow CaCl_2(aq) + H_2(g)$	21.0	58.9	1.500 g Ca
$CaO(s) + 2HCl(aq) \Rightarrow CaCl_2(aq) + H_2O(g)$	21.0	30.2	2.000 g CaO
$H_2(g) + \frac{1}{2}O_2(g) \Rightarrow H_2O(l)$ $\Delta H = -285.8$ kJ			

7

13. 30 L of water in a bomb calorimeter is warmed from 20.00 °C to 23.94 °C when 10 g of butane (C_4H_{10}) is reacted with sufficient oxygen to allow complete combustion. Use this information plus appropriate heats of formation (i.e. values for carbon dioxide, water and oxygen) to derive the heat of formation for the compound butane. Check this answer with the heat of formation value for butane found in the table to see if the information in the question is correct.

14. From the following information determine the percent by mass of a 20 kg block of ice at −30°C that can be converted to water through the combustion of 130 g of octane (C_8H_{18}).

8

$\Delta H_{C_8H_{18}(l)}$ = −250.1 kJ

$\Delta H_{H_20(l)}$ = −285.8 kJ

$\Delta H_{CO_2(g)}$ = −393.5 kJ

specific heat capacity of water = 4.184 J/g °C

specific heat capacity of ice = 2.010 J/g °C

latent heat of fusion for water = 6.03 kJ/mol

Note: do not use Hess' Law in your solution
Hint: start this problem using the heat summation method to determine the $\Delta H_{combustion}$ for octane.

15. From the following information and Hess' Law, calculate the heat of formation of CaO in kJ

a) $CaO(s) + 2HCl(aq) \rightarrow CaCl_2(s) + H_2O(l)$

15.00 g of CaO was reacted in 5 L of an HCl solution.* A change in temperature of 19.6 C was noted

5

b) $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(s) + H_2(g)$

12.00 g of Ca was reacted in 5 L of an HCl solution.* A change in temperature of 8.7 C was noted.

c) $H_2(g) + O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -285.6$ kJ/mol

* consider these solution to have the same heat capacity as water (4.184 J/g°C) and ignore any mass contributions from the addition of CaO and Ca

Heat Summation

(1)

2. Using heats of formation from pg 799 in your text and that $\Delta H^\circ_{Al2O3(s)} = -1866.44$ kJ and $\Delta H^\circ_{Al4C3(s)} = -30.9$ kcal determine the heat of reaction for:

$$Al_2O_3(s) + CH_4(g) \Rightarrow Al_4C_3(s) + H_2O(g)$$

(1)

3. The heat of combustion of octane ($C_8H_{18}(l)$) is -5470.1 kJ. Use $\Delta H^\circ_{CO2(s)} = -393.5$ kJ, $\Delta H^\circ_{H2O(l)} = -285.8$ kJ and the heat summation rule to determine the heat of formation of octane. Once again DO NOT USE THE TABLES IN THE BOOK FOR THIS QUESTION (accept to perhaps check your answer)!!!

(3)

2. Calculate the change in enthalpy for the combustion reaction of oleic acid ($C_{18}H_{34}O_2$). Use tables and the fact that:

$$\Delta H_{C_{18}H_{34}O_2} = -818.81 \text{ kJ/mol}$$

(4)

3. Using the summation of heats of formation technique, calculate the heat of reaction in kJ, if $FeSO_4$ (s) is decomposed to form Fe (s) plus sulphur dioxide gas plus oxygen gas. Use the values in the text for help. Now determine the mass of natural gas (CH_4 (g)) in kg that must be combusted to provide enough heat to decompose 750 kg of ferrous sulphate. Use -922.6 for the heat of formation of FeSO4

(9)

3. Calculate the heat of reaction for:

$$Al(NO_3)_3(aq) + (NH_4)_2SO_4(aq) \Rightarrow Al_2(SO_4)_3(s) + NH_4NO_3(s)$$

Using the following heats of formation and heats of formation listed in your text.

$\Delta H^\circ_{Al(NO3)3(aq)} = -273.65$ kcal
$\Delta H^\circ_{(NH4)2SO4(aq)} = -281.86$ kcal
$\Delta H^\circ_{Al2(SO4)3(s)} = -820.98$ kcal

(11)

2. Determine the heat of combustion of zinc sulphide (ZnS) given that the oxide products are zinc oxide and sulphur dioxide. Use the heat summation method for this determination (i.e. don't use Hess' Law). When you have determined the heat of combustion, write a thermochemical equation that represents this process. You must write a balanced chemical equation before you begin.

(12)

2. Using the table found in your text book, determine the heat of reaction for the decomposition of potassium chlorate.

$$KClO_3(s) \Rightarrow KCl(s) + O_2(g) \quad \Delta H = ?$$

(2)

2. Using the table of values in the back of the text book, determine the heat of combustion of ethyl alcohol. The formula of ethyl alcohol is $C_2H_5OH(l)$. This is not a Hess' law.

2. Use heats of formation directly (i.e. not Hess Law) to calculate the heat of reaction for:

$$3CuO(s) + 2NH_3(g) \Longrightarrow 3Cu(s) + 3H_2O(l) + N_2(g)$$

(5)

Use your answer to determine:

a) the heat released in kJ if 500 g of Cu(s) is recovered

b) the heat released in kcal if 1.5 L of nitrogen gas is recovered at S.T.P. (22.414 L of gas = 1 mol of gas)

Hess' Law

3. Using Hess' Law find the heat of formation of toluene, $C_7H_8(l)$ given:

$C_6H_6(l) + 6H_2(g) \Rightarrow 3C_2H_6(g)$ $\Delta H° = -336.393$ kJ

$C_2H_6(g) + Cl_2(g) \Rightarrow 2CH_3Cl(g)$ $\Delta H° = -79.496$ kJ

$C_7H_8(l) + HCl(g) \Rightarrow C_6H_6(l) + CH_3Cl(g)$ $\Delta H° = -48.953$ kJ

The heat of formation of ethane, $C_2H_6(g)$ is -84.517 kJ

The heat of formation of HCl(g) is -92.048 kJ

If I haven't made a mistake you should be able to check your answer using the tables in the back of the text. Don't forget the conversion to kcal!!!

4. Determine the heat of formation of urea, $CO(NH_2)_2$ using Hess' law from the information given below.

1 $2NH_3(g) + 3H_2O(l) \Rightarrow NH_4NO_3(s) + 4H_2(g)$ $\Delta H = 583.6$ kJ

2 $CH_2O(l) \Rightarrow CO(g) + H_2(g)$ $\Delta H = -1.9$ kJ

3 $CH_2O(l) + 2NH_3(g) \Rightarrow CO(NH_2)_2(s) + 2H_2(g)$ $\Delta H = -133.1$ kJ

4, 5 & 6 heats of formation of CO(g), $H_2O(l)$ and $NH_4NO_3(s)$ are -110.5 kJ, -285.8 kJ and -583.6 kJ respectively

If this question has been written correctly (i.e.Schlank didn't make a mistake, the answer should be -551.5 kJ

7. Use Hess' Law to find the heat of formation of ethane (C_2H_6) given:

① $C_2H_6(g) + \frac{1}{2}Cl_2(g) \Rightarrow C_2H_5Cl(g) + \frac{1}{2}H_2(g)$ $\Delta H° = 8.6$ kJ

② The heat of combustion of ethanol is -1409.2 kJ.

③ $C_2H_5Cl(g) + H_2O(l) \Rightarrow C_2H_5OH(l) + HCl(g)$ $\Delta H° = 33.5$ kJ

④ The heat of formation (and reaction thereof) for carbon dioxide gas.

⑤ The heat of formation (and reaction thereof) for water.

⑥ The heat of formation (and reaction thereof) for hydrogen chloride gas.

See text book for heats of formation and the answer!!

5. Use Hess' Law to determine the heat of formation of p-nitrotoluene ($C_7H_7O_2N$) given:

$C_7H_8(l) + HNO_3(l) \rightarrow C_7H_7O_2N(l) + H_2O(l)$ $\Delta H = -47.25$ kcal

$C_7H_8(l) + 9O_2(g) \rightarrow 7CO_2(g) + 4H_2O(l)$ $\Delta H = -943.1$ kcal

$NO_2(g) + H_2O(l) \rightarrow HNO_3(l) + H_2(g)$ $\Delta H = 18.8$ kcal

Table values for the formation reactions of $CO_2(g)$, $H_2O(l)$ and $NO_2(g)$

3

4. Use Hess' Law (The Law of Hess) to prove that the heat of formation of ethyl alcohol (C_2H_5OH (l)) is -66.4 kcal/mol, using:

a) The combustion of dimethyl ether (CH_3OCH_3 (l)) has a heat of reaction of $\Delta H = -348.6$ kcal

b) The straight conversion (i.e. no other compounds present in the reaction) of dimethyl ether (CH_3OCH_3 (l)) to ethyl alcohol (C_2H_5OH (l))has a heat of reaction of -22.1 kcal

c) the formation reaction for $CO_2(g)$

d) the formation reaction for $H_2O(l)$

Please write out all four equations and the equation for the formation of ethyl alcohol **before** you attempt the Hessian Law!

4

4. Using Hess' Law, determine the heat of formation of acetamide (CH_3CONH_2) from the following information:

① the oxidation of ethyl alcohol produces acetic acid

$C_2H_5OH(l) + \frac{1}{2}O_2(g) \Rightarrow CH_3COOH(l) + H_2(g)$ $\Delta H° = -197.6$ kJ

② ethane can be formed from the addition of hydrogen to ethene

$C_2H_4(g) + H_2(g) \Rightarrow C_2H_6(g)$ $\Delta H° = -136.3$ kJ

③ addition of water to ethene produces ethane

$C_2H_4(g) + H_2O(l) \Rightarrow C_2H_5OH(l)$ $\Delta H° = -287.7$ kJ

④ acetic acid plus ammonia forms acetamide plus water

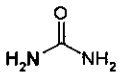
$CH_3COOH(l) + NH_3(g) \Rightarrow CH_3CONH_2(s) + H_2O(l)$ $\Delta H° = 139.5$ kJ

⑤ formation of ammonia gas ($NH_3(g)$) (use text book)

⑥ formation of ethane gas ($C_2H_6(g)$) (use text book)

⑦ formation of water ($H_2O(l)$) (use text book)

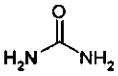
12

5. Using Hess' Law determine heat of formation of urea  from the following information:

① the heat of formation of ammonia ($NH_3(g)$) is -45.9 kJ

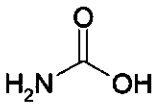
② the heat of combustion of acetic acid  (l) is -925.8 kJ

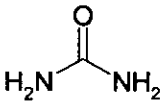
③ the heat of formation of methane ($CH_4(g)$) is -74.4

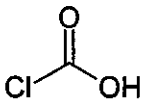
④  (l) + $H_2O(l)$ + $CH_4(g)$ ⇨  (l) + $2NH_3(g)$ ΔH° =169.1 kJ

⑤ the heat of formation of $CO_2(g)$ is -393.5 kJ

⑥ the heat of formation of H_2O (l) is -285.8 kJ







4. Calculate the heat of formation of NH_4Cl using the following equations and Hess' Law (ignore states).

1.	$NH_3 + HCl == NH_4Cl$	ΔH = -176.73 kJ
2.	$N_2 + 3H_2 == 2NH_3$	ΔH = -92.30 kJ
3.	$2HCl + I_2 == 2HI + Cl_2$	ΔH = 236.23 kJ
4.	$H_2 + I_2 == 2HI$	ΔH = 51.80 kJ

Enthalpy Game

1. For each of the following, label with a + or a - where a + indicated an endothermic reaction (i.e. $\Delta H = +$) and a - indicates an exothermic reaction (i.e. $\Delta H = -$). Do not guess, wrong will be subtracted from right.

a) ____ a rotting onion is slowly consumed by special rotting onion bacteria

b) ____ formation of dew overnight

c) ____ formation of hydrogen cyanide from the elements hydrogen, carbon and nitrogen in their natural state at 25 °C and 1 atm pressure

d) ____ boiling water produces water vapour

(12)

e) ____ spontaneous levitation of an entire class of chemistry students

f) ____ zinc and oxygen combine in a combustion reaction to form a common oxide of zinc

g) ____ mixing ammonium nitrate and water is a common reaction used in cold packs (reduces temperature in case of injury)

h) ____ irradiation of stable atoms produces unstable isotopes capable of spontaneous radiative decay processes

i) ____ electricity can be used to separate water molecules into it component elements through electrolysis

j) ____ slow steady growth of a tree is a result of metabolic processes with in the tree

1. For each of the following, decide if the situation represents an increase in potential energy or a decrease in potential energy. Label the increases in potential energy with a "+" sign and the decreases in potential energy with a "-" sign. Proceed carefully. Wrong subtracted from right.

(8)

a) ___ the combustion of methane gas
b) ___ the formation of diamond from coal or graphite deep within the earths crust
c) ___ formation of ice on a window pain through a sublimation process
d) ___ formation of toluene from its constituent elements (l)
e) ___ a reaction in which the reactants have greater forces or attraction than the products
f) ___ evaporation of isopropyl alcohol
g) ___ formation of an onion from all necessary raw materials
h) ___ the conversion of ethyl alcohol to dimethyl ether
i) ___ physical exertion
f) ___ a tree grows in the forest

1. For each of the following, label with a + for in increase in potential energy or a - for a decrease in potential energy. Be careful. One-half mark will be deducted for each incorrect response.

a) ____ The formation of ethyne from its component elements.

b) ____ Sand is used to make glass.

c) ____ Calcium carbonate is formed by the addition of carbon dioxide to calcium oxide.

(9)

d) ____ Growth of a Western Red Cedar (i.e. humongous tree).

e) ____ Cellular respiration.

f) ____ Formation of a cloud.

g) ____ Sublimation of $H_2O(g)$ to $H_2O(s)$.

h) ____ Reaction of propane with oxygen.

i) ____ Reduction of tin (IV) oxide to tin (II) oxide.

j) ____ Conversion of glucose to hexane.

1. For each of the following, label with a + for in increase in potential energy or a - for a decrease in potential energy:

a) ___ the combustion of methane gas

b) ___ the formation of diamond deep within the earths crust

c) ___ formation of ice on a window through a sublimation process

(4)

d) ___ formation of toluene (l)

e) ___ a reaction in which the reactants have greater forces or attraction than the products

f) ___ heat energy is absorbed by the water jacket in a bomb calorimeter (consider reactant and product compounds only)

g) ___ formation of an onion from all necessary raw materials

h) ___ the conversion of ethyl alcohol to dimethyl ether

i) ___ deflation of a balloon

f) ___ build up of electrostatic charge in a thunderhead

1. For each of the following situations, determine if the process represents an increase or a decrease in potential energy. If the process is an increase in potential energy, label it with a "+" sign. If the process is a decrease, label it with a "-" sign. Do not guess. One half mark will be deducted for each incorrect response.

+ / -	situations
	cold water droplets form on a window
	cellular respiration (i.e. the process in which your body converts glucose to useable energy
	a piece of bread slowly becomes dry and hard
	in a thermonuclear process, mass is converted to heat energy
	photosynthesis (i.e. the process in which plants convert carbon dioxide and water to glucose and oxygen gas
	the heat of formation of benzene
	the heat of combustion of benzene
	the heat of formation of ethanol
	the formation of snow
	a light fluffy cloud slowly dissipates leaving clear sunny skies

11

1. For each of the following, label with a + for in increase in potential energy or a - for a decrease in potential energy. Be careful. One-half mark will be deducted for each incorrect response.

a) ___ the combustion of methane gas
b) ___ the formation of diamond deep within the earths crust
c) ___ formation of frost on a window through a sublimation process
d) ___ formation of benzene (l)
e) ___ a reaction in which the reactants have greater forces or attraction than the products
f) ___ heat energy is absorbed by the water jacket in a bomb calorimeter (consider the change in enthalpy of the reaction only)
g) ___ formation of an onion from all necessary raw materials
h) ___ the conversion of ethyl alcohol to dimethyl ether
i) ___ deflation of a balloon
f) ___ build up of electrostatic charge in a thunderhead

10

1. Each of the following examples involve a change in enthalpy. If the change in enthalpy is positive, label with an A. If the change in enthalpy is negative, label with a B. Do not guess! For every two wrong answers, one mark will be subtracted.

a) ____ The lake thaws slowly in the spring.

b) ____ When two particular solutions are mixed together the average temperature increases

c) ____ In a fission reaction , the total mass of the products is significantly less than the total mass of the reactants.

(6)

d) ____ Sulphuric acid is dissolved in water.

e) ____ The products of a reaction have greater attractive forces than the reactants.

f) ____ After a reaction, the forces of attraction between the atoms involved has undergone a net increase.

g) ____ The condensation of any liquid.

h) ____ $H_2O(g) + C(s) = CO(g) + H_2(g)$ H = 31.4 kcal

i) ____ Photosynthesis

j) ____ The formation of water from its elements at 25 C and 1 atmosphere pressure.

The following questions will be graded according to presentation for a total of ten marks!!!! You should have adequate time to consider your approach to presentation.

1. Each of the following examples involve a change in enthalpy. If the change in enthalpy is positive, label with an A. If the change in enthalpy is negative, label with a B. Do not guess! Wrong subtracted from right!

a) ____ The lake thaws slowly in the spring.
b) ____ When two particular solutions are mixed together the average temperature increases
c) ____ In a nuclear fission reaction , the total mass of the products is significantly less than the total mass of the reactants.

(7)

d) ____ Sulphuric acid is dissolved in water.
e) ____ The products of a reaction have greater attractive forces than the reactants.
f) ____ After a reaction, the forces of attraction between the atoms involved has undergone a net increase.
g) ____ The condensation of any liquid.
h) ____ $H_2O(g) + C(s) = CO(g) + H_2(g)$ $\Delta H = 31.4$ kcal
i) ____ Photosynthesis
j) ____ The formation of water from its elements at 25 °C and 1 atmosphere pressure.

1. Each of the following examples involve a change in enthalpy. Label as + for an increase in potential energy and - for a decrease in potential energy Do not guess! One half mark deducted for each wrong answer!

a) _____ The lake thaws slowly in the spring.
b) _____ When two particular solutions are mixed together the average temperature increases
c) _____ In a fission reaction , the total mass of the products is significantly less than the total mass of the reactants.
d) _____ Sulphuric acid is dissolved in water.
e) _____ The products of a reaction have greater attractive forces than the reactants.
f) _____ After a reaction, the forces of attraction between the atoms involved has undergone a net increase.
g) _____ The condensation of any liquid.
h) _____ $H_2O(g) + C(s) = CO(g) + H_2(g)$ $\Delta H = 31.4$ kcal
i) _____ Photosynthesis
j) _____ The formation of water from its elements at 25 C and 1 atmosphere pressure.

(5)

1. Each of the following examples involve a change in enthalpy. If the change in enthalpy is positive, label with an A. If the change in enthalpy is negative, label with a B. Do not guess! One mark for a correct response, minus one half mark for an incorrect response!

a) _____ water in a puddle gradually evaporates
b) _____ when two particular solutions are mixed together the average temperature decreases
c) _____ the sublimation of dry ice i.e $CO_2(s) \Longrightarrow CO_2(g)$
d) _____ $COCl_2(g) \Longrightarrow CO(g) + Cl_2(g)$
e) _____ the reactants of a reaction have stronger bonds than the products
f) _____ after a reaction, the forces of attraction between the atoms involved has undergone a net increase
g) _____ the condensation of any liquid
h) _____ the formation of benzene from its elements at 25 °C and 1 atmosphere pressure
i) _____ photosynthesis
j) _____ the fermentation of glucose to ethyl alcohol plus carbon dioxide i.e. $C_6H_{12}O_6 \Longrightarrow 2C_2H_6O + CO_2$

(3)

1. Determine whether the following circumstances are endothermic or exothermic and label as endo or exo. Do not guess, one half mark deducted for each incorrect response.

(2)

a) _____ ice-cream slowly melts

b) _____ protein molecules from a medium rare steak are digested to form amino acids

c) _____ the smell of frying mushrooms fills a room

d) _____ in the nuclear power reaction used to generate the energy needed to cook the frying mushrooms the mass of uranium fuel becomes less during the reaction

e) _____ vegetables such as potatoes and corn are produced through the process known as photosynthesis

f) _____ the energy one gets after digesting a good meal is due to the abundance of glucose available for the process known as cellular respiration

g) _____ the beautiful smell associated with garlic is thought to form through the rapid combination of two separate molecules once the garlic cells are disturbed

h) _____ the condensation of steam to form water droplets when pasta is cooking is a sure sign that dinner is almost ready

i) _____ the freshness of many different vegetables such as peas and corn can be preserve through rapid freezing

j) _____ when baking a cake sodium bicarbonate (baking soda) is frequently used to cause the cake to rise due to its spontaneous decomposition in the presence of an acid to form carbon dioxide gas thus making the cake light and fluffy! MMMMMMMM!

Word Questions

5. When ammonium nitrate is mixed with water, the resulting solution quickly becomes very cold. Why? (1 mark per major point)

4

6. What are the two fundamental driving forces in thermodynamics?

4

2. What is the difference between Q and ΔH? Why are these two quantities equal in magnitude but opposite of sign for a given chemical or physical change? (1 mark per main point)

4

2. Please write the combustion reaction of hexane ($C_6H_{14}(l)$) as thermodynamic equation and as a thermochemical equation. The heat of combustion of hexane is -4162.9 kJ

9

Bonus

Bonus:

Given the following values at 25 °C and 1 atm pressure:

$\Delta H_{H2O(l)} = -68.32$ kcal
$\Delta H_{H2O(g)} = -57.80$ kcal
$S_{H2O(l)} = 16.72$ cal
$S_{H2O(g)} = 45.11$ cal

(10)

And given: $\Delta G = \Delta H - T\Delta S$

ΔG = Gibb's Free Energy ($\Delta G \leq 0$ for spontaneity)
ΔH = Change in Enthalphy
T = Temperature in Kelvins
ΔS = Change in Entropy

Calculate the temperature above which the physical change of

$H_2O(l) \Rightarrow H_2O(g)$

becomes spontaneous!!!

7. Given that:

a) $\Delta G = \Delta H - T\Delta S$ where: ΔG = Gibb's free energy (J)
ΔH = Enthalpy (J)
T = temperature (K or °C)
ΔS = Entropy

(4)

b) $\Delta G < 0$ for a spontaneous reaction

c) ΔH value is 10 times more significant than the ΔS value

State what the sign (+ or -) is for each of the following situations:

Situation	ΔH sign	ΔS sign
evaporation of any liquid to a gas		
combustion of a hydrocarbon		
solidification of a liquid to a crystal solid		
dissolving of a salt in water becomes cold		
dissolving of a salt in water becomes hot		

Note that this question tests your understanding of chemical potential energy in the ΔH column and your understanding of entropy in the ΔS column.