NAME: HONORS CHEMISTRY

SECTION: Thermodynamics Mixed Problem Set

1. A nutritional chemist burns a saltine cracker in a calorimeter containing 2.50 kg of water. The temperature increases from 25.0°C to 29.8 °C. What is the energy content of the cracker in calories and in kilojoules? The specific heat of water is 4.18 J/g °C and 1.00 cal/g °C

2. Calculate the enthalpy of reaction for the decomposition of cobalt (II) carbonate into cobalt (II) oxide and carbon dioxide gas. ΔH_f^o of cobalt (II) carbonate is –721.9 kJ/mol. Refer to table A-6 in your textbook for enthalpy of formation data. (Hint: start with a balanced equation)

3. Calculate the enthalpy of reaction for the reaction: $2\ N_2(g) + 5\ O_2(g) \rightarrow 2\ N_2O_5(g)$ given the following data:

$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$	ΔH^o = -285.8 kJ
$N_2O_5(g) + H_2O(l) \rightarrow 2\ HNO_3(l)$	ΔH^o = -76.6 kJ
$½\ N_2(g) + 3/2\ O_2(g) + ½\ H_2(g) \rightarrow HNO_3(l)$	ΔH^o = -174.1 kJ

4. What is the heat of reaction for the reduction of iron (II) oxide with carbon monoxide? Use enthalpy of formation data.

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

5. Arrange the following in order of increasing entropy: Hg(l), Hg(s), $C_6H_6(l)$, $CH_3OH(l)$

6. Are these processes exothermic or endothermic? Explain.
   a) forming snowflakes

   b) making I_2 crystals from vapor

   c) condensing steam

   d) vaporizing CO_2 from dry ice

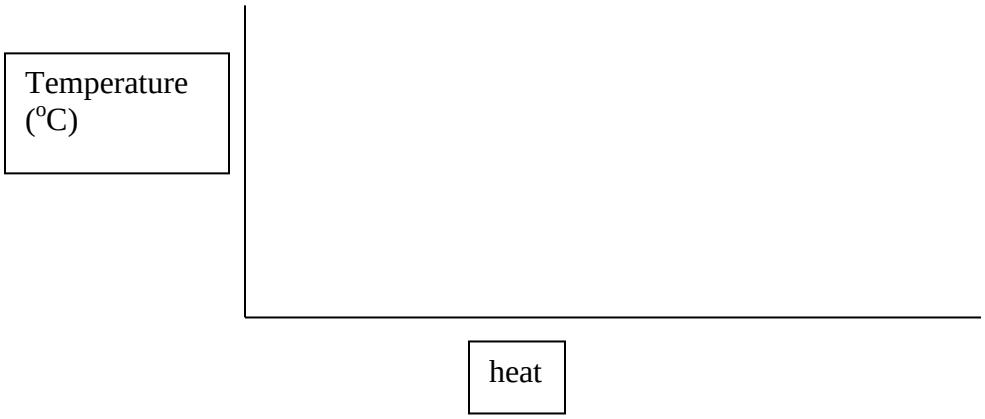
   e) melting ice cream

7. For purposes of space travel, the mass of fuel required is an important factor. The ΔH^o for one mole of fuel is listed after each fuel. Which fuel produces the most heat per gram?
   a) $H_2(g)$, -242 kJ
   b) $CH_4(g)$, -890 kJ
   c) $N_2H_4(l)$, -525 kJ (hydrazine)
   d) $C_3H_4N_3O_9(l)$, -6690 kJ (TNT)

Molar Heat Data for Some Substances

			Examples		
Name	Symbol	Description	Mercury, Hg	Ethanol, C_2H_5OH	Water, H_2O
Heat of fusion	ΔH_{fus}	Energy needed to melt one mole	+ 2.29 kJ/mol mp = -38.8 ^oC	+5.02 kJ/mol mp = -114.1^oC	+6.00kJ/mol mp = 0.0^oC
Heat change for 1.0^oC		Energy needed to raise temp. of one mole by 1^oC	2.80×10^{-2} kJ/mol	1.12×10^{-1} kJ/mol	$.53 \times 10^{-2}$ kJ/mol
Heat of vaporization	ΔH_{vap}	Energy needed to boil one mole	+59.1 kJ/mol bp = 357^oC	+38.6 kJ/mol bp = 78.3^oC	+40.6 kJ/mol bp = 100.0^oC

8. Draw and label a temperature vs. heat curve for 1 mol Hg being heated from a solid at –38.8^oC to a gas at 357^oC.



9. How much energy is required to change 1 mol liquid mercury at –38.8°C to mercury vapor at 357°C?

10. How much energy is required to boil 5.00 mol of ethanol at 78.3°C?

11. How much energy is needed to change 2.3 mol of ice at 0°C to steam at 100°C?

12. Calculate the change in Gibb's free energy (ΔG) for the following reactions at 25°C using the standard free energies of formation provided. Which reactions can happen spontaneously?:

a) $C_4H_8O_3N_2 + H_2O \rightarrow 2C_2H_5O_2N$

Substance	**ΔG^o (kJ)**
CH_4	-51
$C_4H_8O_3N_2$	-490
$C_3H_7O_2N$	-372
$C_2H_5O_2N$	-378
H_2O	-237
NH_3	-26

b) $H_2O \rightarrow H_2 + ½\ O_2$

c) $3CH_4 + NH_3 + 3O_2 \rightarrow C_3H_7O_2N + 4H_2O$

. 13. Consider the synthesis reaction represented by the chemical equation shown in the box below.

$N_{2\,(g)} + 3\ F_{2\,(g)} \rightarrow 2\ NF_{3\,(g)}$ $\quad \Delta H^o = -275$ kJ/mol $\quad \Delta S^o = -282$ J/K mol

Will this reaction occur spontaneously at 35°C? Justify your answer with a calculation.