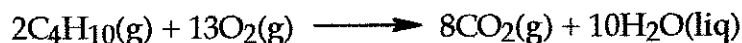


1. Predict the sign of the entropy change to be expected for each of the following transformations:
- (4) a) $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \longrightarrow \text{NH}_4\text{Cl}(\text{s})$ $\Delta\text{S} =$
- (4) b) $\text{N}_2\text{O}(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{N}_2\text{O}_5(\text{g})$ $\Delta\text{S} =$
- (4) 2. In an **endothermic** reaction, the number of kcal required for bond breaking in the reactants is (greater than, less than, equal to) the number of kcal liberated by bond formation in the products.
- (4) 3. Sublimation is an example of a process for which:
- a) ΔH , ΔS , and ΔG are always positive.
b) ΔH and ΔS are always negative.
c) ΔH and ΔS are always positive.
d) ΔH is always positive and ΔS is always negative.
e) The sign of ΔH and ΔS cannot be determined in the absence of the specific identity of reactant and product in the sublimation process.
- (4) 4. For the reaction, $\text{H}_2(\text{g}) + \text{S}(\text{s}) \longrightarrow \text{H}_2\text{S}(\text{g})$ at one atm pressure, the enthalpy change is negative, the entropy change is positive, and the reaction as written is spontaneous at room temperature. Which one of the following statements is also valid?
- a) ΔG for the reaction is positive at room temperature only.
b) The reverse reaction is spontaneous at high temperatures.
c) The reverse reaction is spontaneous at low temperatures.
d) The sign of ΔG for the reaction as written will change with a change in temperature.
e) The reaction as written will be spontaneous at all temperatures above 0°K .
- (4) 5. The internal energy change, ΔE , for a system that absorbs 200 cal of heat from the surroundings at the same time that the surroundings perform 300 cal of work on the system will be:
- a) +500 cal b) +300 cal c) +100 cal d) -100 cal e) -500 cal

- (4) 6. For the reaction, $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g})$ at constant temperature and pressure, which one of the following statements is valid?
- a) $\Delta E = \Delta H$
 - b) ΔE is more endothermic than ΔH
 - c) ΔE is more exothermic than ΔH
 - d) To ascertain a relationship between ΔE and ΔH for the reaction above, the reaction temperature must be known.
 - e) None of the above statements is true.
- (4) 7. For the reaction, $\text{C}(\text{gr}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g})$ at a given temperature, $\Delta G = -10$ kcal. Which one of the following statements is valid?
- a) The system is at equilibrium.
 - b) $\text{CO}_2(\text{g})$ will form spontaneously
 - c) $\text{CO}_2(\text{g})$ will decompose spontaneously.
 - d) The rate of $\text{CO}_2(\text{g})$ formation will be rapid.
 - e) The above reaction, as written, is not possible.
- (4) 8. When 42.5 ml of water at 90°C is mixed with 68.0 ml of water at 25°C (without loss of heat to the surroundings), the final temperature of the combined liquids will be:
- a) 40°C b) 45°C c) 50°C d) 55°C e) 60°C
- (4) 9. When 100.0 g of nickel at 150°C is mixed with 1.0 liter of water at 25°C , the final temperature of the nickel-water mixture is 26.3°C . What is the specific heat of nickel? Assume $D_{\text{water}} = 1.0$ g/ml.
- a) 0.105 cal/ $g^\circ\text{C}$ b) 0.117 cal/ $g^\circ\text{C}$ c) 0.128 cal/ $g^\circ\text{C}$
- d) 0.133 cal/ $g^\circ\text{C}$ e) 0.150 cal/ $g^\circ\text{C}$
- (4) 10. The combustion of 90.0 g of oxalic acid, $\text{C}_2\text{H}_2\text{O}_4$, in a bomb calorimeter whose heat capacity is 4.60 kJ/ $^\circ\text{C}$ causes the temperature to rise from 25.0°C to 79.6°C . What is the molar heat of combustion of oxalic acid?
- a) -217.6 kJ/mol b) -225.1 kJ/mol c) -251.2 kJ/mol
- d) -289.9 kJ/mol e) -314.8 kJ/mol

- (4) 11. The standard enthalpy of vaporization of hydrogen chloride is 3.86 kcal/mol, and the standard entropy of vaporization of hydrogen chloride is 20.5 cal/mol^oK. The boiling point of hydrogen chloride, in ^oC, is:
- a) -188.3^oC b) +188.3^oC c) -34.0^oC d) -84.9^oC e) +84.9^oC
- (5) 12. The oxidation of 1.000 g of powdered tantalum metal to produce Ta₂O₅ liberates 1.377 kcal. The standard enthalpy of formation of Ta₂O₅ must be:
- a) +498.4 kcal/mol b) +249.2 kcal/mol c) -124.6 kcal/mol
d) -249.2 kcal/mol e) -498.4 kcal/mol
- (9) 13. Determine the standard enthalpy of formation of butane, C₄H₁₀, given the following data at 25^oC and one atm pressure:



Standard enthalpy of reaction = -1376.0 kcal
 Standard enthalpy of formation of CO₂(g) = -94.0 kcal/mol
 Standard enthalpy of formation of H₂O(liq) = -68.3 kcal/mol
 Show all work in the space provided below.

- (9) 14. Determine the average C-F bond energy based on the data provided below. Show all work in the space provided below.

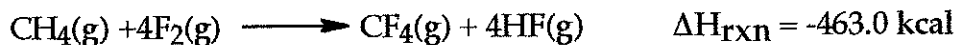


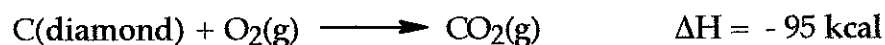
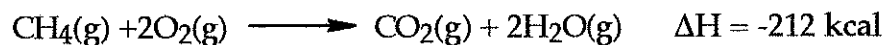
Table of Bond Energies

<u>Bond</u>	<u>kcal/mol</u>
F-F	37.0
C-H	99.3
H-F	135.0

- (8) 15. A chronically and severely underpaid chemist, Dr. I. M. N. Sane, has conceived of a scheme to create diamonds by burning methane gas as illustrated below:



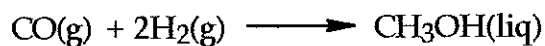
- a) Determine the enthalpy change for the above transformation based on the known enthalpy changes for the following reactions:



- b) In thermochemical terms, why would it be unwise to invest your limited life savings to underwrite the above scheme (despite your response to the first part of this question)?

- (9) 16. The combustion of 1.710 g of cane sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, in a bomb calorimeter causes the temperature of 980.0 g of H_2O to increase from 24.92°C to 30.92°C . Determine the heat of combustion of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ in kcal/mol. Show all work in the space provided. Be sure to specify whether the heat of combustion is ΔH or ΔE . The specific heat of water may be assumed to be $1.0 \text{ cal/g}^\circ\text{C}$.

- (12) 17. Methanol (wood alcohol) can be prepared by heating carbon monoxide gas and hydrogen gas under pressure in the presence of a catalyst according to the equation shown below:



Determine the enthalpy change for the above reaction given the following data. Show all work in the space provided below.

