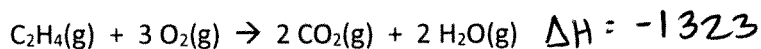
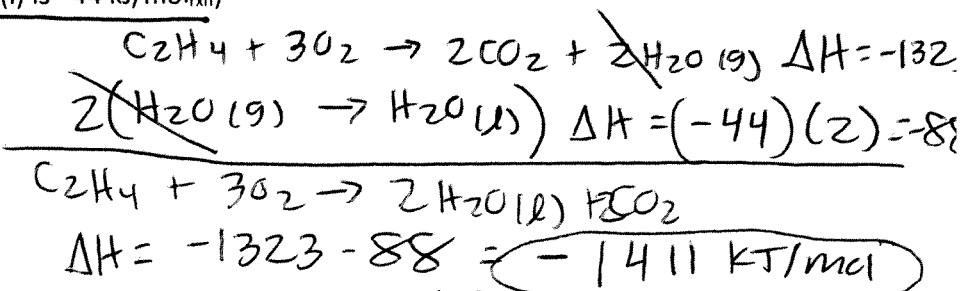


Thermochemistry Study Guide – Multiple Choice

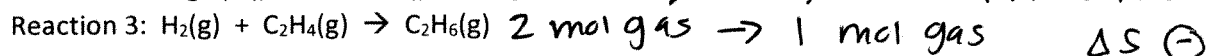
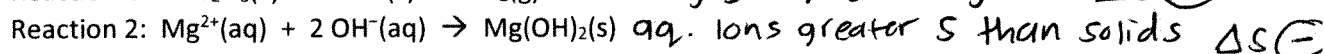
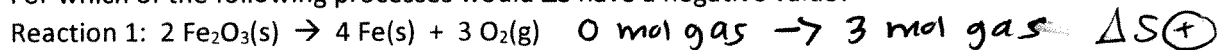


1. For the reaction of ethylene represented above, ΔH is $-1,323 \text{ kJ/mol}_{\text{rxn}}$. What is the value of ΔH if the combustion produced liquid water $\text{H}_2\text{O}(\text{l})$, rather than water vapor $\text{H}_2\text{O}(\text{g})$? (ΔH for the phase change $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ is $-44 \text{ kJ/mol}_{\text{rxn}}$)

- (A) $-1,279 \text{ kJ/mol}_{\text{rxn}}$
 (B) $-1,323 \text{ kJ/mol}_{\text{rxn}}$
 (C) $-1,367 \text{ kJ/mol}_{\text{rxn}}$
 (D) $-1,411 \text{ kJ/mol}_{\text{rxn}}$



2. For which of the following processes would ΔS have a negative value?



- (A) Reaction 1 only
 (B) Reactions 1 and 2 only
 (C) Reactions 1 and 3 only
 (D) Reactions 2 and 3 only



3. The reaction indicated above is thermodynamically favorable at 298 K, but becomes unfavorable at higher temperatures. Which of the following is true at 298 K?

- (A) ΔG , ΔH , and ΔS are all positive.
 (B) ΔG , ΔH , and ΔS are all negative.
 (C) ΔG and ΔH are negative, but ΔS is positive.
 (D) ΔG and ΔS are negative, but ΔH is positive.

$$\Delta G = \Delta H - T\Delta S$$

$\ominus \quad \ominus \quad \ominus$

Higher T = Bigger $T\Delta S$
 = more positive ΔG

4. A student observes that an open container of water left overnight in the laboratory experienced a good deal of evaporation. Which of the following sets of conditions best describes the thermodynamics of this evaporation event?

- (A) $\Delta H > 0$, $\Delta S > 0$
 (B) $\Delta H > 0$, $\Delta S < 0$
 (C) $\Delta H < 0$, $\Delta S > 0$
 (D) $\Delta H < 0$, $\Delta S < 0$

Evaporation

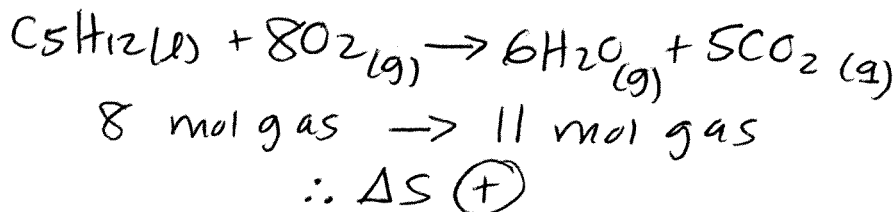
Liquid \rightarrow Gas Making more gas $\therefore \Delta S \oplus$

ENDOTHERMIC

$\therefore \Delta H \oplus$

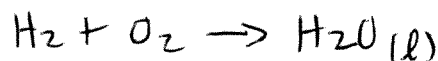
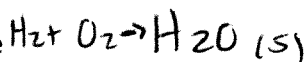
5. Which of the following thermodynamics quantities best describe the combustion of liquid pentane, $C_5H_{12}(l)$, to form $H_2O(g)$ and $CO_2(g)$ at 1 atm?

- (A) $\Delta H > 0, \Delta S > 0$
 (B) $\Delta H > 0, \Delta S < 0$
 (C) $\Delta H < 0, \Delta S > 0$
 (D) $\Delta H < 0, \Delta S < 0$



6. Compared to the value of ΔH°_f for $H_2O(s)$, the value of ΔH°_f for $H_2O(l)$ has the

- (A) Opposite sign and smaller absolute value
 (B) Same sign and smaller absolute value
 (C) Same sign and greater absolute value
 (D) Opposite sign and greater absolute value



E released for both, but solid H_2O is more organized than liquid. Thus solid formation releases more E.

7. The reaction for the synthesis of hexane from ethyne is shown above. Based on the data presented in the table below, which of the following is the standard enthalpy change, ΔH° , for the reaction represented above?

Substance	ΔH°_f
$C_2H_2(g)$	230 kJ/mol _{rxn}
$C_6H_6(g)$	83 kJ/mol _{rxn}

- (A) -607 kJ/mol_{rxn}
 (B) -147 kJ/mol_{rxn}
 (C) -19 kJ/mol_{rxn}
 (D) $+19$ kJ/mol_{rxn}

$$\Delta H = 83 - 3(230)$$

$$= 83 - 690 = -607$$

8. Which of the following reactions has the largest positive value of ΔS per mole of Cl_2 ?

- (A) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$
 (B) $Cl_2(g) + \frac{1}{2}O_2(g) \rightarrow Cl_2O(g)$
 (C) $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$
 (D) $2NH_4Cl(s) \rightarrow N_2(g) + 4H_2(g) + Cl_2(g)$



9. Which of the following must be true for a reaction that is thermodynamically favorable from initial standard state conditions?

Spontaneous

- (A) $\Delta G^\circ > 0$ and $K_{eq} > 1$
 (B) $\Delta G^\circ > 0$ and $K_{eq} < 1$
 (C) $\Delta G^\circ < 0$ and $K_{eq} > 1$
 (D) $\Delta G^\circ < 0$ and $K_{eq} < 1$

10. Of the following reactions, which involves the largest decrease in entropy?

- (A) $2 \text{CO(g)} + \text{O}_2\text{(g)} \rightarrow 2 \text{CO}_2\text{(g)}$ 3 mol gas \rightarrow 2 mol gas
 (B) $\text{Pb(NO}_3)_3\text{(s)} + 2 \text{KI(s)} \rightarrow \text{PbI}_2\text{(s)} + 2 \text{KNO}_3\text{(s)}$ 3 mol solid \rightarrow 3 mol solid
 (C) $\text{C}_3\text{H}_8\text{(g)} + \text{O}_2\text{(g)} \rightarrow 3 \text{CO}_2\text{(g)} + 4 \text{H}_2\text{O(g)}$ 2 mol gas \rightarrow 7 mol gas
 (D) $4 \text{La(s)} + 3 \text{O}_2\text{(g)} \rightarrow 2 \text{La}_2\text{O}_3\text{(s)}$ 3 mol gas \rightarrow 0 mol gas

11. When solid NH_4SCN is mixed with solid Ba(OH)_2 in a closed container, the temperature drops and a gas is produced. Which of the following indicates the correct sigs for ΔG , ΔH , and ΔS for the process?

sys gains
surr lose
heat
 $\therefore \Delta H (+)$

solid + solid \rightarrow gas

$\therefore \Delta S (+)$

- | | ΔG | ΔH | ΔS |
|-----|------------|------------|------------|
| (A) | + | - | - |
| (B) | - | + | - |
| (C) | - | + | + |
| (D) | + | - | + |

12. A 10. g cube of copper at a temperature T_1 is placed in an insulated cup containing 10. g of water at a temperature T_2 . If $T_1 > T_2$, which of the following is true of the system when it has attained thermal equilibrium? (The specific heat of copper is $0.385 \text{ J/g}\cdot^\circ\text{C}$ and the specific heat of water is $4.18 \text{ J/g}\cdot^\circ\text{C}$)

Same
T \rightarrow

- (A) The temperature of the copper changed more than the temperature of the water.
 (B) The temperature of the water changed more than the temperature of the copper.
 (C) The temperature of the water and the copper changed by the same amount.
 (D) The relative temperature changes of the copper and the water cannot be determined without knowing T_1 and T_2 .

copper has lower specific heat

$\therefore \text{Cu changes } T \text{ more}$

spontaneous

13. If the reaction $A + B \rightleftharpoons C$ has an equilibrium constant, K , greater than 1. Which of the following statements is true?

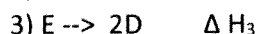
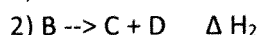
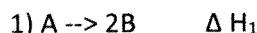
- (A) The reaction is nonspontaneous and favors the reactants.
- (B) The reaction is spontaneous and favors the reactants.
- (C) The reaction is nonspontaneous and favors the products.
- (D) The reaction is spontaneous and favors the products.

14. As a result of an exothermic reaction,

- (A) the energy of the system is increased and the energy of the surroundings are decreased.
- (B) the energy of the system and the energy of the surroundings are increased.
- (C) the energy of the system and the energy of the surroundings are decreased.
- (D) the energy of the system is decreased and the energy of the surroundings are increased.

system releases E into surroundings

15. Consider the following numbered processes:



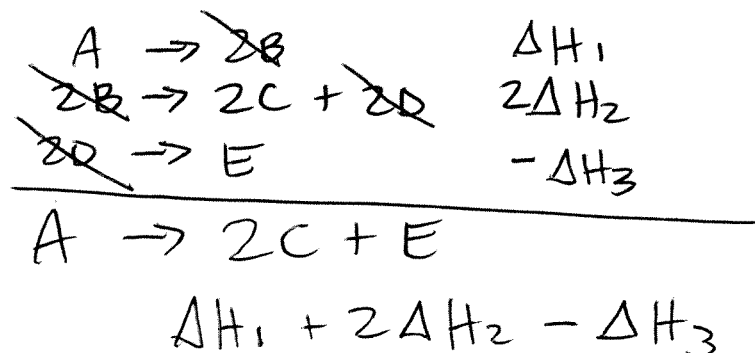
ΔH for the process $A \rightarrow 2C + E$ is

(A) $2 \Delta H_1 + 2 \Delta H_2 - \Delta H_3$

(B) $2 \Delta H_1 + \Delta H_2 - \Delta H_3$

(C) $\Delta H_1 + 2 \Delta H_2 - \Delta H_3$

(D) $\Delta H_1 + \Delta H_2 + \Delta H_3$



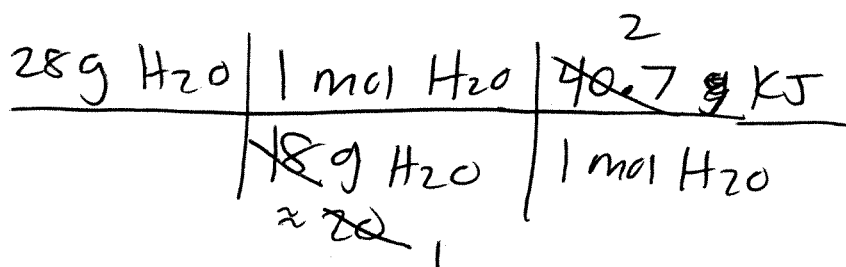
16. How much heat is required to vaporize 28 g of water? ΔH_{vap} of water is 40.7 kJ/mol.

(A) 20.4 kJ

(B) 40.7 kJ

(C) 63.2 kJ

(D) 81.4 kJ



$$\approx 28 \times 2 = 56$$