This print-out should have 6 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Bomb Calorimeter 006
001 10.0 points

Assuming the apparatus itself absorbs no heat, what will be the change in temperature if 1000 mL of water are used as a heat sink for a reaction that releases 8 kJ of heat?

1. 1.91 K **correct**

2. 8.00 K

3. -271.09 °C

4. -265 °C

5. -1.91 K

Explanation:

$q = m \cdot c \cdot \Delta T$

$$8,000\text{ J} = (1000\text{ g}) \cdot (4.184\ \frac{\text{J}}{\text{g} \cdot \text{K}}) \cdot \Delta T$$

$\Delta T = 1.91$ K

LDE Hess' Law 006
002 10.0 points

Calculate the change in enthalpy for the combustion of graphite using the data below.

$H_2(g) + \frac{1}{2}O_2(g) \longleftrightarrow H_2O(l)$
$\Delta H = -285.83\text{ kJ} \cdot \text{mol}^{-1}$

$CO_2(g) + 2H_2O(l) \longleftrightarrow CH_4(g) + 2O_2(g)$
$\Delta H = 882.00\text{ kJ} \cdot \text{mol}^{-1}$

$C_{graphite}(s) + 2H_2(g) \longleftrightarrow CH_4(g)$
$\Delta H = -74.87\text{ kJ} \cdot \text{mol}^{-1}$

$C_{graphite}(s) + O_2(g) \longleftrightarrow CO_2(g)$
$\Delta H = ?$

1. $-230.04\text{ kJ} \cdot \text{mol}^{-1}$

2. $521.30\text{ kJ} \cdot \text{mol}^{-1}$

3. $-515.87\text{ kJ} \cdot \text{mol}^{-1}$

4. $-386.41\text{ kJ} \cdot \text{mol}^{-1}$ **correct**

5. $235.47\text{ kJ} \cdot \text{mol}^{-1}$

Explanation:

In order for the three provided reactions to cancel to result in the unknown reaction (the combustion of graphite), the first reaction needs to be reversed and doubled, the second needs to be reversed, and the third will remain unchanged. Consequently, the overall change in enthalpy for the reaction is: $\Delta H_{rxn} = -2 \times -285.83 + -1 \times 882.00 + -74.87 = -386.41\text{ kJ} \cdot \text{mol}^{-1}$

LDE Thermodynamic Work 0034
003 10.0 points

For which of the following reactions at room temperature (25 °C) would there be 5.0 kJ of work done on the system?

1. $N_2H_2(g) + CH_3OH(g) \rightarrow CH_2O(g) + N_2(g) + 2H_2(g)$

2. $CH_2O(g) + N_2(g) + 2H_2(g) \rightarrow N_2H_2(g) + CH_3OH(g)$ **correct**

3. $CO_2(g) + 2H_2O(g) \rightarrow CH_4(g) + 2O_2(g)$

4. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

5. $2H_2O(l) + O_2(g) \rightarrow 2H_2O_2(l)$

6. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Explanation:

At room temperature (298 K), the product of the gas constant ($R = 8.314\text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$) and T is very close to $2.5\text{ kJ} \cdot \text{mol}^{-1}$. Based on the equation 5.0 kJ = $-\Delta n_{gas} \cdot 2.5\text{ kJ} \cdot \text{mol}^{-1}$, the reaction for which Δn_{gas} is -2 will be the correct answer.

LDE Entropy 002
004 10.0 points

Which of the reactions below will likely have the largest increase in entropy (ΔS_{rxn})?

1. $C_5H_{12}(l) + 8O_2(g) \rightarrow 6H_2O(g) + 5CO_2(g)$ **correct**

2. $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

3. $S_3(g) + 9F_2(g) \rightarrow 3SF_6(g)$

4. $2CH_4(g) + 2O_3(g) \rightarrow 4H_2O(g) + 2CO(g)$

5. $N_2H_4(g) + H_2(g) \rightarrow 2NH_3(g)$

Explanation:
The reaction with the greatest positive value for Δn_{gas} will have the greatest value of ΔS_{rxn}.

LDE Sign Conventions 004
005 10.0 points

The formation of ammonia from hydrogen and nitrogen gases becomes less and less spontaneous as temperature is increased, eventually becoming non-spontaenous at sufficiently high temperatures. Which of the following statements must be true?

1. The change in entropy is large.

2. The reaction is endothermic.

3. The reaction is exothermic. **correct**

4. The change in entropy is small.

Explanation:
Since the reaction becomes more and more spontaneous as the temperature is lowered, it must be spontaneous at T = 0 K. Since ΔG = ΔH at T = 0 K, ΔH must be negative and the reaction is exothermic.

LDE Stat Thermo Energy 002
006 10.0 points

How much energy would be associated with the non-vibrational motion of 2 moles of N_2?

1. $\frac{5}{2}kT$

2. $3RT$

3. $5RT$ **correct**

4. $5kT$

5. $6kT$

6. $\frac{5}{2}RT$

Explanation:
Total number of motional modes is equal to 3 times the number of atoms in the molecule. In the case of N_2, this is 6. It has 3 translational and 2 rotational modes (rather than 3, because it is linear). The sixth and final mode is vibrational; for a total of 5 non-vibrational modes. This would amount to 5RT, 2 moles times 1/2 RT per mode times 5 modes.