This print-out should have 21 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points

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

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

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

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

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

1. $-385.21\ \text{kJ} \cdot \text{mol}^{-1}$

2. $-515.87\ \text{kJ} \cdot \text{mol}^{-1}$

3. $521.30\ \text{kJ} \cdot \text{mol}^{-1}$

4. $-230.04\ \text{kJ} \cdot \text{mol}^{-1}$

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

002 10.0 points

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

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

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

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

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

5. $2CH_4(g) + 2O_3(g) \rightarrow 4H_2O(g) + 2CO(g)$

003 10.0 points

What is true about the first law of thermodynamics?

1. $\Delta E_{\text{univ}} < 0$

2. $\Delta E_{\text{univ}} = 0$

3. $\Delta E_{\text{sys}} = 0$

4. $\Delta E_{\text{sys}} < 0$

5. $\Delta E_{\text{sys}} > 0$

6. $\Delta E_{\text{univ}} > 0$

004 10.0 points

Which of

$O_2(g)$, $O_2(\ell)$, $H_2(g)$, $H_2(\ell)$, $H_2O(g)$, $H_2O(\ell)$

have a heat of formation equal to zero?

1. $O_2(g)$, $O_2(\ell)$, $H_2(g)$, $H_2(\ell)$, $H_2O(g)$, $H_2O(\ell)$

2. $O_2(g)$, $O_2(\ell)$, $H_2(g)$, $H_2(\ell)$

3. All of them, but only at absolute zero

4. $O_2(g)$, $H_2(g)$

5. $O_2(g)$, $H_2(g)$, $H_2O(g)$

005 10.0 points

If 25.0 g of water at 100.0 °C are mixed with 15.0 g of water at 40.0 °C, what temperature will the 40.0 g of combined water be at once they reach equilibrium?

1. 70.0 °C

2. 77.5 °C

3. 60.0 °C

4. 62.5 °C

006 10.0 points

Calculate the reaction enthalpy for the formation

$$2\,\mathrm{Al(s)} + 3\,\mathrm{Cl_2(g)} \longrightarrow 2\,\mathrm{AlCl_3(s)}\,,$$

of anhydrous aluminum chloride using the data

$2\,\mathrm{Al(s)} + 6\,\mathrm{HCl(aq)} \longrightarrow 2\,\mathrm{AlCl_3(aq)} + 3\,\mathrm{H_2(g)}$ $\Delta H^\circ = -1049$ kJ

$\mathrm{HCl(g)} \longrightarrow \mathrm{HCl(aq)}$ $\Delta H^\circ = -74.8$ kJ

$\mathrm{H_2(g)} + \mathrm{Cl_2(g)} \longrightarrow 2\,\mathrm{HCl(g)}$ $\Delta H^\circ = -185$ kJ

$\mathrm{AlCl_3(s)} \longrightarrow \mathrm{AlCl_3(aq)}$ $\Delta H^\circ = -323$ kJ

1. −1883.5 kJ

2. −1100.36 kJ

3. −1225.7 kJ

4. −1502.4 kJ

5. −1450.85 kJ

6. −1406.8 kJ

7. −1826.2 kJ

007 10.0 points

The pressure-volume work done by an ideal gaseous system at constant volume is

1. $-\dfrac{\Delta P}{P}$

2. zero

3. $-\Delta E$

4. q

5. $-V\,\Delta P$

008 10.0 points

A CD player and its battery together do 500 kJ of work, and the battery also releases 250 kJ of energy as heat and the CD player releases 50 kJ as heat due to friction from spinning. What is the change in internal energy of the system, with the system regarded as the battery and CD player together?

1. −700 kJ

2. −200 kJ

3. −800 kJ

4. −750 kJ

5. +200 kJ

009 10.0 points

Which of the following would probably have a positive ΔS value?

1. $\mathrm{He(g,\ 2\ atm)} \rightarrow \mathrm{He(g,\ 10\ atm)}$

2. $\mathrm{H_2(g)} + \mathrm{I_2(s)} \rightarrow 2\,\mathrm{HI(g)}$

3. $2\,\mathrm{NO_2(g)} \rightarrow \mathrm{N_2O_4(g)}$

4. $\mathrm{O_2(g)} \rightarrow \mathrm{O_2(aq)}$

5. $2\,\mathrm{Ag(s)} + \mathrm{Br_2}(\ell) \rightarrow 2\,\mathrm{AgBr(s)}$

010 10.0 points

Which of the following statements is always true?

1. An exothermic reaction is spontaneous.

2. If the number of moles of gas does not change in a chemical reaction, then $\Delta S^0 = 0$.

3. A reaction for which delta S^0 is positive is spontaneous.

4. If ΔH^0 and ΔS^0 are both positive, ΔG^0 will decrease as the temperature increases.

011 10.0 points

For the reaction

$$2\,\mathrm{SO_3(g)} \rightarrow 2\,\mathrm{SO_2(g)} + \mathrm{O_2(g)}$$

$\Delta H^\circ_\mathrm{r} = +198\ \mathrm{kJ \cdot mol^{-1}}$ and $\Delta S^\circ_\mathrm{r} = 190\ \mathrm{J \cdot K^{-1} \cdot mol^{-1}}$ at 298 K. The forward reaction will be spontaneous at

1. temperatures above 1042 K.

2. all temperatures.

3. temperatures above 1315 K.

4. temperatures below 1042 K.

5. no temperature.

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012 10.0 points

Which of the following is **not** a definition of enthalpy or change in enthalpy?

1. A measure of the motional energy of a system.

2. A correction for internal energy that accounts for pressure-volume work.

3. A measure of the heat of a system at constant pressure.

4. A measure of a system's ability to change the entropy of its surroundings.

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013 10.0 points

Which of the following quantities is **not** path independent?

1. entropy (S)

2. volume (V)

3. pressure (P)

4. heat (q)

5. enthalpy (H)

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014 10.0 points

Which of the following would experience the smallest increase in temperature if 1 kJ of heat were added to it?

1. 1 g of copper metal

2. 10 g of water

3. 10 g of copper metal

4. 1 g of water

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015 10.0 points

Given the following data:

$3CO_2(g) + 4H_2O(l) \longleftrightarrow C_3H_8(g) + 5O_2(g)$
$\Delta H = 1,110 \text{ kJ} \cdot \text{mol}^{-1}$

$H_2O(l) \longleftrightarrow H_2(g) + 1/2O_2(g)$
$\Delta H = 142.5 \text{ kJ} \cdot \text{mol}^{-1}$

$3C_{\text{graphite}} + 4H_2(g) \longleftrightarrow C_3H_8(g)$
$\Delta H = -52 \text{ kJ} \cdot \text{mol}^{-1}$

calculate ΔH for the reaction

$C_{\text{graphite}} + O_2(g) \longleftrightarrow CO_2(g)$

1. $-592 \text{ kJ} \cdot \text{mol}^{-1}$

2. $-543 \text{ kJ} \cdot \text{mol}^{-1}$

3. $-197 \text{ kJ} \cdot \text{mol}^{-1}$

4. $543 \text{ kJ} \cdot \text{mol}^{-1}$

5. $1202 \text{ kJ} \cdot \text{mol}^{-1}$

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016 10.0 points

Rank the following reactions from least to greatest in terms of change in entropy (ΔS_{rxn}):

a) $KNO_3(aq) + NaCl(aq) \longrightarrow NaNO_3(aq) + KCl(aq)$
b) $4Ag(s) + O_2(g) \longrightarrow 2Ag_2O(s)$
c) $2H_2O_2(\ell) \longrightarrow 2H_2O(g) + O_2(g)$
d) $NaHCO_3(s) \longrightarrow NaOH(s) + CO_2(g)$

1. b < a < c < d

2. a < b < d < c

3. c < d < b < a

4. b < a < d < c

5. a < d < b < c

6. d < c < a < b

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017 10.0 points

Phosphine (the common name for PH3, a highly toxic gas used for fumigation), has a $\Delta H^{\circ}_{vap} = 14.6\,\mathrm{kJ \cdot mol^{-1}}$ and a $S^{\circ}_{vap} = 78.83\,\mathrm{J \cdot mol^{-1} \cdot K^{-1}}$. What is the normal boiling point of phosphine expressed in centigrade?

1. 185.2 °C

2. −0.2 °C

3. −87.8 °C

4. 273 °C

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018 10.0 points

Which of the following combustion reactions does not occur at high temperature?

I) $C_6H_{12}O_6(s) + 6O_2(g) \longleftrightarrow 6CO_2(g) + 6H_2O(g)$

II) $2H_2(g) + O_2(g) \longleftrightarrow 2H_2O(g)$

III) $C_3H_8(g) + 5O_2(g) \longleftrightarrow 3CO_2(g) + 4H_2O(g)$

1. II, III

2. II only

3. III only

4. I, II

5. I, II, III

6. I, III

7. I only

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019 10.0 points

(For this problem assume that the calorimeter itself absorbs no heat, the density of water is $1.00\,\mathrm{g \cdot mL^{-1}}$*, and the specific heat capacity of water is* $4.184\,\mathrm{J \cdot g^{-1} \cdot K^{-1}}$*.)*

1.14 g of octane (C_8H_{18}) is combusted in a bomb calorimeter surrounded by 1 L of water. The initial and final temperatures of the water are 25 °C and 38 °C respectively. Determine the molar enthalpy of combustion of octane.

1. $-5,440\,\mathrm{kJ \cdot mol^{-1}}$

2. $-54,400\,\mathrm{kJ \cdot mol^{-1}}$

3. $-54.4\,\mathrm{kJ \cdot mol^{-1}}$

4. $-544\,\mathrm{kJ \cdot mol^{-1}}$

5. $-5.44\,\mathrm{kJ \cdot mol^{-1}}$

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020 10.0 points

If both Δn_{gas} and Δn for a particular reaction are zero, which statement below would be the most accurate prediction we could make about the change in entropy?

1. It is definitely positive.

2. It may be either positive or negative and is probably very small.

3. It is definitely negative.

4. It may be either positive or negative and is probably very large.

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021 10.0 points

Which of the following statements concerning internal energy is/are true?

I) If the expansion work is small, ΔH and ΔU are close in value.

II) ΔU for a system is equal to q at constant volume.

III) Assuming no heat is exchanged, when pressure-volume work is done on the system, ΔU is positive.

1. I, II, III

2. II only

3. III only

4. I, III

5. I only

6. II, III

7. I, II