

This print-out should have 40 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Carbon Allotropes 001

001 5.0 points

Based on your knowledge of carbon allotropes, You can say that ΔG_f° of graphite is _____ and ΔG_{rxn}° of diamond \rightarrow graphite is _____.

1. zero, large
2. small, negative
3. large, small
4. positive, positive
5. zero, negative **correct**
6. large, zero

Explanation:

The standard state of carbon is graphite; consequently, graphite's standard free energy of formation is zero. Diamond is actually thermodynamically less stable than graphite; consequently, diamond's reversion to graphite is spontaneous.

First Law Thermo 01

002 5.0 points

What is true about the first law of thermodynamics?

1. $\Delta E_{\text{univ}} = 0$ **correct**
2. $\Delta E_{\text{univ}} > 0$
3. $\Delta E_{\text{univ}} < 0$
4. $\Delta E_{\text{sys}} < 0$
5. $\Delta E_{\text{sys}} > 0$
6. $\Delta E_{\text{sys}} = 0$

Explanation:

Msci 15 0505

003 5.0 points

For a reaction in which gases are neither produced nor consumed, ΔH is

1. the same as ΔE . **correct**
2. less than ΔE .
3. unrelated to ΔE .
4. greater than ΔE .

Explanation:

For a reaction at constant temperature and constant pressure, $\Delta E = \Delta H - (\Delta n)RT$.

If gases are neither produced nor consumed, Δn will be zero, so ΔE must equal ΔH .

Spontaneous Endo Signs alt

004 5.0 points

What are the signs of ΔS_{surr} , ΔS_{sys} , and ΔS_{univ} , respectively, for a spontaneous endothermic reaction?

1. $-$, $+$, $+$ **correct**
2. $+$, $-$, $-$
3. $+$, $+$, $+$
4. Cannot be predicted with certainty from the given information
5. $-$, $+$, $-$

Explanation:

Thermo Signs

005 5.0 points

When water condenses, what are the signs for q , w , and ΔS_{sys} , respectively?

1. $+$, $-$, $+$
2. $-$, $+$, $+$
3. $+$, $-$, $-$

4. –, +, – **correct**

5. +, +, –

6. +, +, +

Explanation:

LDE Definitions in Thermo 011

006 5.0 points

Which of the following state functions are extensive?

- I) Pressure (P)
- II) Temperature (T)
- III) Enthalpy (H)

1. II, III

2. None are true

3. II only

4. I only

5. I, II

6. I, III

7. III only **correct**

8. I, II, III

Explanation:

Examples of extensive state functions include: mass, volume, enthalpy, entropy, internal energy, free energy etc.

Heat of Formation

007 5.0 points

Which of

$\text{O}_2(\text{g})$, $\text{O}_2(\ell)$, $\text{H}_2(\text{g})$, $\text{H}_2(\ell)$, $\text{H}_2\text{O}(\text{g})$, $\text{H}_2\text{O}(\ell)$

have a heat of formation equal to zero?

1. $\text{O}_2(\text{g})$, $\text{O}_2(\ell)$, $\text{H}_2(\text{g})$, $\text{H}_2(\ell)$

2. $\text{O}_2(\text{g})$, $\text{H}_2(\text{g})$ **correct**

3. $\text{O}_2(\text{g})$, $\text{H}_2(\text{g})$, $\text{H}_2\text{O}(\text{g})$

4. All of them, but only at absolute zero

5. $\text{O}_2(\text{g})$, $\text{O}_2(\ell)$, $\text{H}_2(\text{g})$, $\text{H}_2(\ell)$, $\text{H}_2\text{O}(\text{g})$, $\text{H}_2\text{O}(\ell)$

Explanation:

Molecules in their native state at STP have a heat of formation of zero.

CIC Specific Heat 1 W

008 5.0 points

Consider the following specific heats: copper, $0.384 \text{ J/g}\cdot^\circ\text{C}$; lead, $0.159 \text{ J/g}\cdot^\circ\text{C}$; water, $4.18 \text{ J/g}\cdot^\circ\text{C}$; glass, $0.502 \text{ J/g}\cdot^\circ\text{C}$. Which substance, once warmed, would be more likely to maintain its heat and keep you warm through a long football game on a cold night?

1. copper

2. water **correct**

3. lead

4. glass

Explanation:

Water has the highest specific heat of the substances listed, so it has the capacity to emit the largest quantity of heat with minimal temperature loss; the emitted heat keeps you warm. The substance continues to warm you until its temperature is at or below your body temperature.

Mlib 05 0003

009 5.0 points

4.7 g of a hydrocarbon fuel is burned in a calorimeter that contains 263 grams of water initially at 25.00°C . After the combustion, the temperature is 26.55°C . How much heat is evolved per gram of fuel burned? The heat capacity of the calorimeter (hardware only) is $92.3 \text{ J/}^\circ\text{C}$.

1. 362 J/g

2. 393 J/g **correct**

3. 143 J/g
4. 6246 J/g
5. 27652 J/g
6. 5883 J/g
7. 1848 J/g
8. 1705 J/g

Explanation:

$$m_{\text{fuel}} = 4.7 \text{ g} \qquad m_{\text{water}} = 263 \text{ g}$$

$$\Delta T = 26.55^\circ\text{C} - 26.00^\circ\text{C} = 1.55^\circ\text{C}$$

The amount of heat evolved by the reaction is equal to the amount of heat gained by the water plus the amount of heat gained by the calorimeter.

The specific heat of water is $4.184 \text{ J/g}\cdot^\circ\text{C}$, so we have to multiply by grams and temperature change in order to obtain Joules:

$$\begin{aligned} \Delta H \text{ of water} &= (\text{SH})(m_{\text{water}})(\Delta T) \\ &= (4.184 \text{ J/g}\cdot^\circ\text{C})(263 \text{ g}) \\ &\quad \times (1.55^\circ\text{C}) \\ &= 1705 \text{ J} \end{aligned}$$

The heat capacity of the calorimeter is $92.3 \text{ J/}^\circ\text{C}$. This is not per gram, so we just have to multiply by the temperature change to get Joules:

$$\begin{aligned} \Delta H \text{ of calorimeter} &= (\text{SH})(\Delta T) \\ &= (92.3 \text{ J/}^\circ\text{C})(1.55^\circ\text{C}) \\ &= 143 \text{ J} \end{aligned}$$

$$\begin{aligned} \Delta H \text{ of rxn} &= \Delta H \text{ of water} \\ &\quad + \Delta H \text{ of calorimeter} \\ &= 1705 \text{ J} + 143 \text{ J} = 1848 \text{ J} \end{aligned}$$

This is the amount of heat evolved. To get the amount per gram of fuel burned, we divide ΔH of the reaction by the amount of fuel burned (4.7 grams):

$$\frac{1848 \text{ J}}{4.7 \text{ g}} = 393 \text{ J/g}$$

LDE Bomb Calorimeter 007**010** 5.0 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. 62.5°C
3. 60.0°C
4. 77.5°C **correct**

Explanation:

$$q_{\text{cold}} = -q_{\text{hot}}$$

$$15 \cdot 4.184 \cdot (T_f - 40) = -25 \cdot 4.184 \cdot (T_f - 100)$$

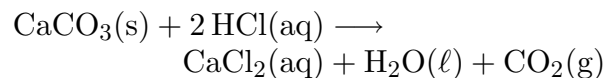
$$15 \cdot (T_f - 40) = -25 \cdot (T_f - 100)$$

$$40 \cdot T_f = 3100$$

$$T_f = 77.5^\circ\text{C}$$

ChemPrin3e 06 58**011** 5.0 points

Calculate the standard reaction enthalpy for the reaction of calcite with hydrochloric acid



The standard enthalpies of formation are:

- for $\text{CaCl}_2(\text{aq})$: -877.1 kJ/mol ;
- for $\text{H}_2\text{O}(\ell)$: -285.83 kJ/mol ;
- for $\text{CO}_2(\text{g})$: -393.51 kJ/mol ;
- for $\text{CaCO}_3(\text{s})$: -1206.9 kJ/mol ;
- and for $\text{HCl}(\text{aq})$: -167.16 kJ/mol .

1. -215 kJ/mol
2. -116 kJ/mol
3. -98.8 kJ/mol
4. -165 kJ/mol
5. -38.2 kJ/mol
6. -72.7 kJ/mol
7. -15.2 kJ/mol **correct**

Explanation:

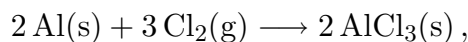
We use Hess' Law:

$$\begin{aligned}
 \Delta H^\circ &= \sum n \Delta H_{j,\text{prod}}^\circ - \sum n \Delta H_{j,\text{reac}}^\circ \\
 &= \Delta H_{f, \text{CaCl}_2(\text{aq})}^\circ + \Delta H_{f, \text{H}_2\text{O}(\ell)}^\circ \\
 &\quad + \Delta H_{f, \text{CO}_2(\text{g})}^\circ - \left[\Delta H_{f, \text{CaCO}_3(\text{s})}^\circ \right. \\
 &\quad \left. + 2 \left(\Delta H_{f, \text{HCl}(\text{aq})}^\circ \right) \right] \\
 &= -877.1 \text{ kJ/mol} + (-285.83 \text{ kJ/mol}) \\
 &\quad + (-393.51 \text{ kJ/mol}) \\
 &\quad - \left[-1206.9 \text{ kJ/mol} \right. \\
 &\quad \left. + 2(-167.16 \text{ kJ/mol}) \right] \\
 &= -15.22 \text{ kJ/mol}.
 \end{aligned}$$

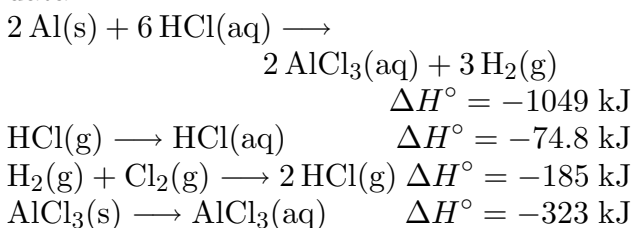
ChemPrin3e 06 60

012 5.0 points

Calculate the reaction enthalpy for the formation



of anhydrous aluminum chloride using the data

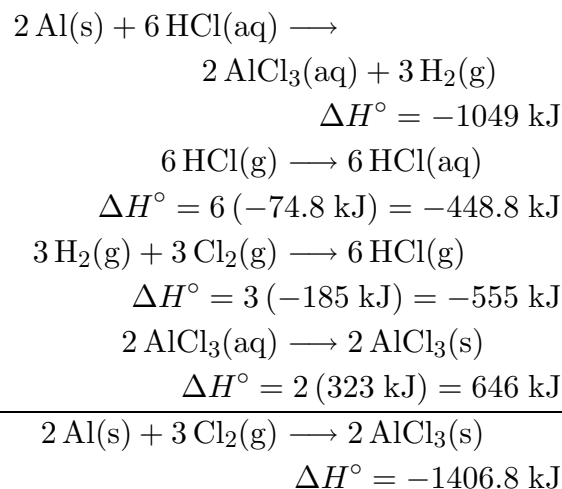


1. -1826.2 kJ
2. -1406.8 kJ **correct**
3. -1450.85 kJ
4. -1502.4 kJ
5. -1883.5 kJ
6. -1225.7 kJ
7. -1100.36 kJ

Explanation:

Using Hess' Law:

The desired reaction is obtained by adding reaction 1; 6 times reaction 2; 3 times reaction 3; and 2 times the reverse of reaction 4:



Internal Energy

013 5.0 points

What are the translational and rotational energies, respectively, for a mole of I_3^- ?

1. $\frac{3}{2} RT$, RT **correct**
2. $\frac{3}{2} kT$, $\frac{3}{2} kT$
3. $\frac{3}{2} RT$, $\frac{3}{2} RT$
4. $3 RT$, $3 RT$
5. $\frac{3}{2} kT$, kT

Explanation:

Translational Energy

014 5.0 points

What is the internal energy associated with the translation of six water molecules?

1. $3 RT$
2. $18 kT$
3. $9 kT$ **correct**
4. $9 RT$

5. $6kT$ **Explanation:**

The energy is $\frac{3}{2}kT$ per mole, so for the six water molecules,

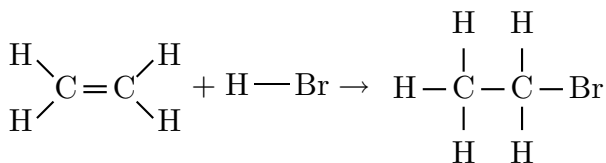
$$6 \left(\frac{3}{2} kT \right) = 9kT$$

ChemPrin3e T02 50**015** 5.0 points

Estimate the heat released when ethene ($\text{CH}_2=\text{CH}_2$) reacts with HBr to give $\text{CH}_3\text{CH}_2\text{Br}$. Bond enthalpies are

C—H : 412 kJ/mol; C—C : 348 kJ/mol;
 C=C : 612 kJ/mol; C—Br : 276 kJ/mol;
 Br—Br : 193 kJ/mol; H—Br : 366 kJ/mol.

- 470 kJ/mol
- 200 kJ/mol
- 424 kJ/mol
- 58 kJ/mol **correct**
- 1036 kJ/mol

Explanation:

$$\begin{aligned} \Delta H &= \sum E_{\text{break}} - \sum E_{\text{make}} \\ &= \left[(\text{C}=\text{C}) + (\text{H}-\text{Br}) \right] \\ &\quad - \left[(\text{C}-\text{H}) + (\text{C}-\text{Br}) + (\text{C}-\text{C}) \right] \\ &= (612 \text{ kJ/mol} + 366 \text{ kJ/mol}) \\ &\quad - \left[412 \text{ kJ/mol} + 276 \text{ kJ/mol} \right. \\ &\quad \left. + 348 \text{ kJ/mol} \right] \\ &= -58 \text{ kJ/mol}, \end{aligned}$$

so 58 kJ/mol of heat was released.

Msci 15 0107**016** 5.0 points

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

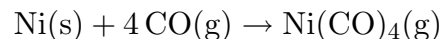
- $-V \Delta P$
- $-\frac{\Delta P}{P}$
- zero **correct**
- q
- $-\Delta E$

Explanation:

When $V = \text{constant}$, nothing moves through a distance and therefore no work is done: $w = 0$.

Msci 15 0115**017** 5.0 points

Consider the reaction



Assuming the gases are ideal, calculate the work done on the system at a constant pressure of 1 atm at 75°C for the conversion of 1.00 mole of Ni to Ni(CO)_4 .

- $1.16 \times 10^4 \text{ J}$
- $2.89 \times 10^3 \text{ J}$
- $5.79 \times 10^3 \text{ J}$
- $1.80 \times 10^3 \text{ J}$
- $8.68 \times 10^3 \text{ J}$ **correct**
- $1.87 \times 10^3 \text{ J}$

Explanation:

$$T = 75^\circ\text{C} + 273 = 348 \text{ K} \quad n_{\text{Ni}} = 1 \text{ mol}$$

$$n_i = 1 \text{ mol Ni} \cdot \frac{4 \text{ mol CO}}{1 \text{ mol Ni}} = 4 \text{ mol}$$

$$n_f = 1 \text{ mol Ni} \cdot \frac{1 \text{ mol Ni(CO)}_4}{1 \text{ mol Ni}} = 1 \text{ mol}$$

$$\Delta n = (1 - 4) \text{ mol} = -3 \text{ mol}$$

$$\begin{aligned} w &= -P \Delta V = -\Delta n RT \\ &= -(-3 \text{ mol}) \cdot \frac{8.31451 \text{ J}}{\text{mol} \cdot \text{K}} \cdot 348 \text{ K} \\ &= 8680.35 \text{ J} \end{aligned}$$

LDE Thermodynamic Theory 008

018 5.0 points

From the standpoint of statistical thermodynamics what is the fundamental origin of internal energy?

1. The motion of individual molecules and the energy associated with that motion. **correct**
2. The observation that the entropy of the universe is always increasing.
3. The observation that the energy in the universe is conserved.
4. The presence of small amounts of entropy in any non-ideal solid even at absolute zero.

Explanation:

$E = 0.5kT$ is the fundamental relation between motion and internal energy.

Bomb Calorimetry

019 5.0 points

Which of the following is NOT a feature of the bomb calorimetry apparatus used to measure the internal energy of a reaction?

1. The thermometer is inserted directly into the reaction vessel to measure ΔT of the reaction. **correct**
2. The volume of the reaction vessel is held constant to eliminate energy released as work.
3. The large heat capacity of water is beneficial in measuring heat released by combustion reactions.
4. Large quantities of water surrounding the

reaction vessel absorb the majority of the heat loss.

5. The heat capacity of the calorimeter should be known to accurately correct for any heat lost to it.

Explanation:

The thermometer is placed in the water that surrounds the reaction vessel.

ChemPrin3e T06 10

020 5.0 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. -200 kJ
2. -750 kJ
3. -800 kJ **correct**
4. -700 kJ
5. +200 kJ

Explanation:

Heat *from* the CD player is -50 kJ.

Heat *from* the battery is -500 kJ.

Work *from both together* on the *surroundings* is -250 kJ.

This question is testing your ability to see what the system is, and then look at **ONLY** the energy flow for the system. Here the system is the battery and the CD player together.

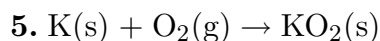
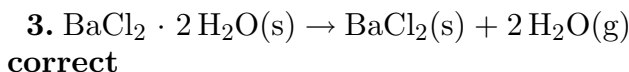
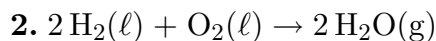
$$\begin{aligned} \Delta U &= q + w \\ &= [-50 \text{ kJ} + (-250 \text{ kJ})] + (-500 \text{ kJ}) \\ &= -800 \text{ kJ} \end{aligned}$$

ChemPrin3e T07 33

021 5.0 points

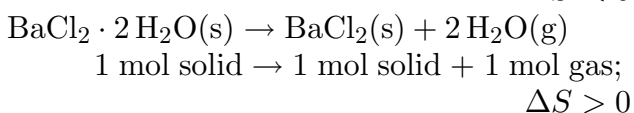
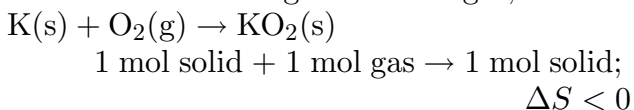
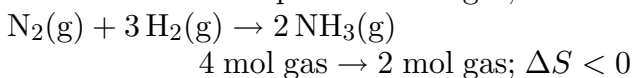
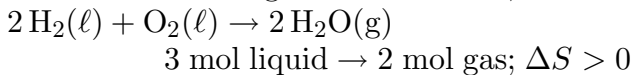
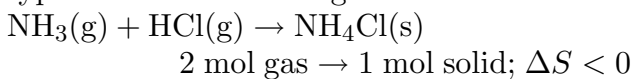
Which of the following reactions has the largest value of ΔS° ?

1. $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$

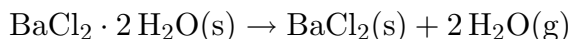


Explanation:

We can predict the sign and magnitude of ΔS by noting the relative order of entropy: solids (lowest) < liquids < solutions < gases (highest) and the number of moles of each type. For the reactions given we have



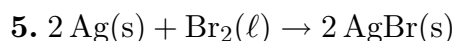
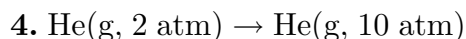
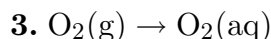
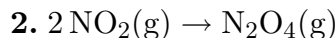
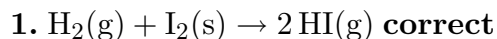
The greatest increase in S would be for the reaction



ChemPrin3e T07 34

022 5.0 points

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

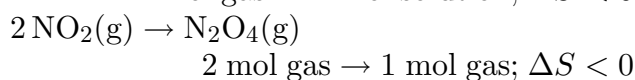
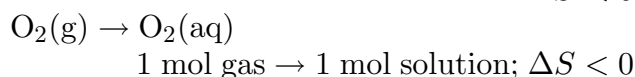
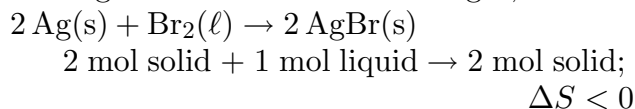
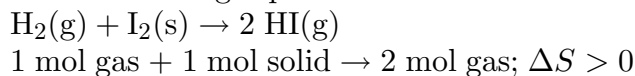
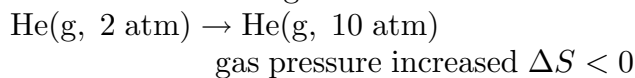


Explanation:

We can predict the sign of ΔS by noting the relative order of entropy: solids (lowest)

< liquids < solutions < gases (highest) and the number of moles of each type. Also, if a gas is compressed (pressure increased) its entropy decreases.

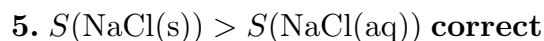
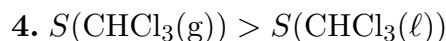
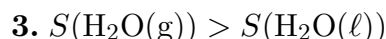
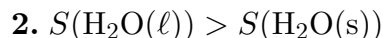
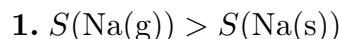
For the reactions given we have



Msci 15 1208

023 5.0 points

Which of the following inequalities concerning the absolute entropy per mole at 25°C is INCORRECT?



Explanation:

Of the states of matter, solids are the most ordered and gases are the least ordered. The entropy of any substance increases as the substance goes from solid to liquid to gas. Solutions are also inherently more disordered than pure substances. Thus the correct choice is $S(\text{NaCl}(\text{s})) > S(\text{NaCl}(\text{aq}))$, because by dissolving the NaCl, it becomes more disordered; i.e., higher in entropy.

ChemPrin3e T07 11

024 5.0 points

Calculate the standard entropy of condensation of chloroform at its boiling point (335

K). The standard molar enthalpy of vaporization of chloroform at its boiling point is $31.4 \text{ kJ} \cdot \text{mol}^{-1}$.

- $+506 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
- $+31.4 \text{ kJ} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
- $-31.3 \text{ kJ} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
- $-93.7 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ **correct**
- $+93.7 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

Explanation:

$$\begin{aligned} \Delta H_{\text{vap}} &= -31.4 \text{ kJ} \cdot \text{mol}^{-1} & T_{\text{BP}} &= 335 \text{ K} \\ &= -31400 \text{ J} \cdot \text{mol}^{-1} \end{aligned}$$

$$\begin{aligned} \Delta S_{\text{cond}} &= \frac{q}{T} = \frac{\Delta H_{\text{con}}}{T_{\text{BP}}} = \frac{-\Delta H_{\text{vap}}}{T_{\text{BP}}} \\ &= \frac{-31400 \text{ J} \cdot \text{mol}^{-1}}{335 \text{ K}} \\ &= -93.7313 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \end{aligned}$$

Mlib 05 3049

025 5.0 points

For which of the following processes does the entropy of the universe decrease?

- None of these is correct. **correct**
- freezing one mole of water to ice at 0°C
- melting one mole of ice to water at 0°C
- freezing one mole of water to ice at 0°C and then cooling it to -10°C
- freezing one mole of water to ice at -10°C

Explanation:

For spontaneous changes, the entropy of the universe increases.

Msci 15 1302

026 5.0 points

Generally speaking, entropy will increase when

- temperature is decreased.
- heat is added to a system. **correct**
- the volume occupied by a group of molecules decreases.
- there is a phase change from liquid to solid.
- mixtures are separated into pure components.

Explanation:

Entropy will INCREASE when volumes increase, temperatures increase, and anytime a mixture becomes more disordered. A liquid to solid phase change is a decrease in entropy. Thus the correct choice is that heat is added to the system – which typically results in a temperature increase.

ChemPrin3e 07 20

027 5.0 points

Based on the structures of each of the following molecules,

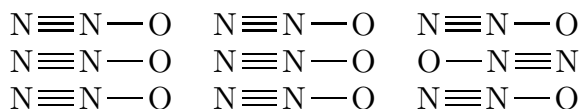
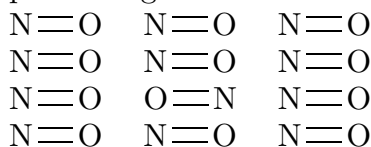
A) NO B) Cl_2 C) CO_2 D) N_2O
which would be most likely to have a residual entropy in their crystal forms at $T = 0$?

- A and C only
- C and D only
- All have residual entropy.
- A and D only **correct**
- A and B only
- B and C only
- None of these responses is correct.
- B and D only

Explanation:

We would expect NO and N_2O to be the

most likely to have a residual entropy at 0 K, since the structures are set up so that the O and N atoms (which are of similar size) could be oriented in one of two ways without perturbing the lattice of the solid, as shown.



Because CO_2 and Cl_2 are symmetrical, switching ends of the molecule does not result in increased disorder.

LDE Stat Thermo Theory 004

028 5.0 points

Assuming you had 1 mole of each of the species below, for which species would the actual residual entropy be closest to the predicted residual entropy? (Hint: think in terms of $S = k \cdot \ln W$ and ideality)

1. FBr
2. BrI **correct**
3. FCl
4. ClI

Explanation:

All of the species have dipole-dipole interactions that make completely random orientations less likely as they form a crystal near absolute zero. The species with the weakest dipole moment will most closely approximate completely random orientations and will have an actual residual entropy closer to to the predicted residual entropy. The ΔEN of the species BrI, FCl, FBr and ClI are 0.3, 0.82, 1.02 and 0.5 respectively. The relative value of ΔEN can be inferred based on knowledge of the electronegativity trend.

Positional Entropy 01

029 5.0 points

Which of the following has the largest posi-

tional entropy at 0 K?

1. two NH_3 molecules
2. four CO molecules
3. sixteen O_2 molecules
4. three BCl_2F molecules **correct**
5. eight CCl_4 molecules

Explanation:

Entropy SiC59

030 5.0 points

Imagine that one carbon in buckminsterfullerene (C_{60}) is replaced by a silicon atom, yielding SiC_{59} . This molecule can then orient in 60 different ways. What is the entropy of one mole of SiC_{59} at $T = 0$ K?

1. 27.3 kJ/K
2. 34.0 J/K **correct**
3. 5.65×10^{-23} J/K
4. 4.53×10^{-20} J/K

Explanation:

$$\begin{aligned} n &= 1 \text{ mol} & k &= 1.38066 \times 10^{-23} \text{ J/k} \\ W &= 60 & N_A &= 6.02214 \times 10^{23} \text{ mol}^{-1} \end{aligned}$$

$$\begin{aligned} S &= n k N_A \ln W \\ &= (1 \text{ mol})(1.38066 \times 10^{-23} \text{ J/k}) \\ &\quad \times (6.02214 \times 10^{23} \text{ mol}^{-1}) \ln(60) \\ &= 34.0425 \text{ J/K} \end{aligned}$$

ChemPrin3e T07 01

031 5.0 points

Calculate the change in entropy of a large pail of water after 200 J of energy is reversibly transferred to the water at 20°C .

1. $-0.683 \text{ J} \cdot \text{K}^{-1}$
2. $-0.733 \text{ J} \cdot \text{K}^{-1}$

3. $+0.733 \text{ J} \cdot \text{K}^{-1}$

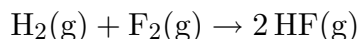
4. $+0.683 \text{ J} \cdot \text{K}^{-1}$ correct

5. $-200 \text{ J} \cdot \text{K}^{-1}$

Explanation:

$$T = 20^\circ\text{C} + 273.15 = 293.15 \text{ K}$$

$$\Delta S = \frac{q}{T} = \frac{200 \text{ J}}{293.15 \text{ K}} = +0.6822 \frac{\text{J}}{\text{K}}.$$

ChemPrin3e T07 39**032** 5.0 pointsCalculate $\Delta S_{\text{surr}}^\circ$ at 298 K for the reaction

$$\Delta H_{\text{r}}^\circ = -546 \text{ kJ} \cdot \text{mol}^{-1} \text{ and } \Delta S_{\text{r}}^\circ = +14.1 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}.$$

1. $-1830 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

2. $+1820 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

3. $+14.1 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

4. $+1832 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ correct

5. $-14.1 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

Explanation:

$$\Delta H_{\text{r}}^\circ = 546000 \text{ J} \cdot \text{mol}^{-1} \quad T = 298 \text{ K}$$

$$\begin{aligned} \Delta S_{\text{surr}}^\circ &= \frac{q_{\text{surr}}}{T} = \frac{-q}{T} = \frac{-\Delta H_{\text{r}}^\circ}{298 \text{ K}} \\ &= \frac{-(-546000 \text{ J} \cdot \text{mol}^{-1})}{298 \text{ K}} \\ &= +1832.21 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}. \end{aligned}$$

BP Benzene**033** 5.0 points

What is the boiling point of benzene if it has a standard heat of vaporization of 30.8 kJ/mol and a standard entropy of vaporization of 87.2 J/mol · K?

1. 100°C

2. -272.6°C

3. 353°C

4. 80°C correct

5. 0.35 K

Explanation:

$$\Delta H_{\text{vap}} = 30.8 \text{ kJ/mol} = 30800 \text{ J/mol}$$

$$\Delta S_{\text{vap}} = 87.2 \text{ J/mol} \cdot \text{K}$$

$$\begin{aligned} T_{\text{BP}} &= \frac{\Delta H_{\text{vap}}}{\Delta S_{\text{vap}}} \\ &= \frac{30800 \text{ J/mol}}{87.2 \text{ J/mol} \cdot \text{K}} \\ &= 353.211 \text{ K} \\ &= 80.211^\circ\text{C} \end{aligned}$$

LDE Thermo 2nd Law Calc 007**034** 5.0 pointsYour friend left two moles of rocky road ice cream out in the sun and all of it melted. Assuming that $\Delta H = 4.74 \text{ kJ} \cdot \text{mol}^{-1}$ and $\Delta S = 18.4 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ for ice cream melting and that the temperature outside was 35°C , by how much in total has your friend increased the entropy of the universe?

1. $18.4 \text{ J} \cdot \text{K}^{-1}$

2. $36.8 \text{ J} \cdot \text{K}^{-1}$

3. $6.02 \text{ J} \cdot \text{K}^{-1}$ correct

4. $3.01 \text{ J} \cdot \text{K}^{-1}$

5. $0 \text{ J} \cdot \text{K}^{-1}$

Explanation:

$$\Delta S_{\text{surr}} = -\frac{\Delta H}{T} = -\frac{4740 \text{ J} \cdot \text{mol}^{-1}}{308 \text{ K}}$$

$$= -15.39 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

$$\Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$$

$$= 3.01 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

the total increase is $(2 \cdot 3.01) \text{ J} \cdot \text{K}^{-1}$

$$= 6.02 \text{ J} \cdot \text{K}^{-1}$$

Msci 15 1414

035 5.0 points

Which of the following statements is always true?

1. A reaction for which ΔS^0 is positive is spontaneous.

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

3. An exothermic reaction is spontaneous.

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

Explanation:

$$\Delta H = (+)$$

$$\Delta S = (+)$$

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

$$= (+) - T (+)$$

$$= (+) - T$$

As T increases, ΔG decreases.

Msci 15 1406a

036 5.0 points

Consider the equation



carefully, and think about the sign of ΔS for the reaction it describes. $\Delta H = +188.3 \text{ kJ}$. Which response describes the thermodynamic spontaneity of the reaction?

1. The reaction is not spontaneous at any temperatures.

2. All responses are correct.

3. The reaction is spontaneous at all temperatures.

4. The reaction is spontaneous only at relatively high temperatures. **correct**

5. The reaction is spontaneous only at relatively low temperatures.

Explanation:

Entropy (S) is high for systems with high degrees of freedom, disorder or randomness and low for systems with low degrees of freedom, disorder or randomness.

$$S(\text{g}) > S(\text{l}) > S(\text{s}).$$

A reaction is spontaneous only when ΔG is negative. ΔH is positive for this reaction and ΔS is positive.

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

$$= (+) - T (+)$$

$$= (+) - T$$

ΔG will be negative (spontaneous reactions) only at high values of T .

ChemPrin3e T07 61

037 5.0 points

For the reaction



$\Delta H_r^\circ = +198 \text{ kJ} \cdot \text{mol}^{-1}$ and $\Delta S_r^\circ = 190 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ at 298 K. The forward reaction will be spontaneous at

1. temperatures above 1315 K.

2. no temperature.

3. all temperatures.

4. temperatures above 1042 K. **correct**

5. temperatures below 1042 K.

Explanation:

$$\Delta H_r^\circ = +198 \text{ kJ/mol} \quad \Delta S_r^\circ = 0.191 \frac{\text{kJ}}{\text{mol} \cdot \text{K}}$$

$$\Delta G^0 = \Delta H^0 - T \Delta S$$

$\Delta G^0 < 0$ for a spontaneous reaction, so

$$\begin{aligned} 0 &> \Delta H^0 - T \Delta S \\ T &> \frac{\Delta H^0}{\Delta S^0} \\ &= \frac{198 \text{ kJ/mol}}{0.019 \frac{\text{kJ}}{\text{mol}\cdot\text{K}}} = 1042.11 \text{ K} \end{aligned}$$

Thus the temperature would need to be $> 1042.11 \text{ K}$.

ChemPrin3e 07 53

038 5.0 points

Which of the compounds

- I) $\text{SO}_2(\text{g})$;
- II) $\text{NO}(\text{g})$;
- III) $\text{HCN}(\text{g})$;
- IV) $\text{PCl}_5(\text{g})$;

is/are unstable and will decompose into their elements under standard conditions at 25°C ?

	ΔH_f° ($\frac{\text{kJ}}{\text{mol}}$)	S° ($\frac{\text{J}}{\text{K}\cdot\text{mol}}$)	ΔG_f° ($\frac{\text{kJ}}{\text{mol}}$)
$\text{SO}_2(\text{g})$	-296.83	248.22	-300.19
$\text{NO}(\text{g})$	90.25	210.76	86.55
$\text{HCN}(\text{g})$	135.1	201.78	124.7
$\text{PCl}_5(\text{g})$	-374.9	364.6	-305.0

1. II, III, and IV only
2. II and IV only
3. III only
4. I, II and IV only
5. Another combination
6. I and III only
7. I, II and III only
8. Cannot be determined
9. I only
10. II and III only **correct**

Explanation:

Examine the standard free energies of formation of the compounds.

Compounds with a negative free energy of formation are stable, whereas those with a positive free energy are unstable with respect to the elements that compose them. Accordingly, only SO_2 and $\text{PCl}_5(\text{g})$ are thermodynamically stable while $\text{HCN}(\text{g})$ and $\text{NO}(\text{g})$ are unstable.

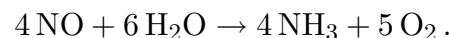
Msci 15 1422

039 5.0 points

From the following data (at 298 K),

Substance	ΔH_f^0 kcal/mol	S^0 cal/mol·K
NO	22.0	50.0
H_2O	-68.0	17.0
NH_3	-11.0	46.0
O_2	0.0	49.0

find ΔG^0 for the reaction



The answer is closest to

1. +100 kcal/mol.
2. +300 kcal/mol.
3. +200 kcal/mol.
4. +250 kcal/mol. **correct**
5. +150 kcal/mol.

Explanation:

$$\begin{aligned} \Delta H_{\text{rxn}}^0 &= \sum n \Delta H_{f,\text{prod}} - \sum n \Delta H_{f,\text{rct}} \\ &= [4(-11.0 \text{ kcal/mol})] \\ &\quad - [4(22.0 \text{ kcal/mol}) \\ &\quad\quad\quad + 6(-68.0 \text{ kcal/mol})] \\ &= 276 \text{ kcal/mol} \end{aligned}$$

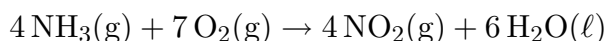
$$\begin{aligned} \Delta S_{\text{rxn}}^0 &= \sum n S_{\text{prod}} - \sum n S_{\text{rct}} \\ &= [5(49 \text{ cal/mol}\cdot\text{K})] \end{aligned}$$

$$\begin{aligned}
 &+ 4(46 \text{ cal/mol} \cdot \text{K}) \\
 &- [4(50 \text{ cal/mol} \cdot \text{K}) \\
 &\quad + 6(17 \text{ cal/mol} \cdot \text{K})] \\
 &= 127 \text{ cal/mol} \cdot \text{K} \\
 &= 0.127 \text{ kcal/mol} \cdot \text{K}
 \end{aligned}$$

$$\begin{aligned}
 \Delta G^0 &= \Delta H^0 - T \Delta S^0 \\
 &= 276 \text{ kcal/mol} \\
 &\quad - (298 \text{ K})(0.127 \text{ kcal/mol} \cdot \text{K}) \\
 &= 238.154 \text{ kcal/mol} \\
 &\approx 250 \text{ kcal/mol}
 \end{aligned}$$

Msci 15 1422M**040** 5.0 points

Calculate the standard Gibbs free energy at 298 K for the reaction



Species	ΔH_f^0 kJ/mol	S^0 J/mol · K
NH ₃ (g)	-46.11	192.3
O ₂ (g)	0.0	205.0
NO ₂ (g)	+33.2	240.0
H ₂ O(ℓ)	-285.8	69.91

- +1398 kJ/mol rxn
- 825 kJ/mol rxn
- +1152 kJ/mol rxn
- +244, 363 kJ/mol rxn
- +825 kJ/mol rxn
- 1643 kJ/mol rxn
- +1643 kJ/mol rxn
- 180, 455 kJ/mol rxn

9. -1398 kJ/mol rxn**10.** -1152 kJ/mol rxn **correct****Explanation:**

$$\begin{aligned}
 \Delta H_{\text{rxn}}^0 &= \sum n \Delta H_{\text{f,prod}}^0 - \sum n \Delta H_{\text{f,rct}}^0 \\
 &= [6(-285.8 \text{ kJ/mol}) \\
 &\quad + 4(33.2 \text{ kJ/mol})] \\
 &\quad - 4(-46.11 \text{ kJ/mol}) \\
 &= -1397.56 \text{ kJ/mol}
 \end{aligned}$$

$$\begin{aligned}
 \Delta S_{\text{rxn}}^0 &= \sum n \Delta S_{\text{f,prod}}^0 - \sum n \Delta S_{\text{f,rct}}^0 \\
 &= [6(69.91 \text{ J/mol} \cdot \text{K}) \\
 &\quad + 4(240.0 \text{ J/mol} \cdot \text{K})] \\
 &\quad - [7(205.0 \text{ J/mol} \cdot \text{K}) \\
 &\quad + 4(192.3 \text{ J/mol} \cdot \text{K})] \\
 &= -824.74 \text{ J/mol} \cdot \text{K} \\
 &= -0.82474 \text{ kJ/mol} \cdot \text{K}
 \end{aligned}$$

$$\begin{aligned}
 \Delta G^0 &= \Delta H^0 - T \Delta S^0 \\
 &= -1397.56 \text{ kJ/mol} \\
 &\quad - (298 \text{ K})(-0.82474 \text{ kJ/mol} \cdot \text{K}) \\
 &= -1151.79 \text{ kJ/mol}
 \end{aligned}$$