

REVIEWING THERMODYNAMICS

1. Which of the following pairs of substances is likely to have the higher positional entropy? Circle your choice. This means you will be circling one member of each pair.

- a) $\text{HCl}_{(\text{aq})}$ or $\text{HCl}_{(\text{g})}$
 b) $\text{H}_2\text{O}_{(\text{s})}$ or $\text{H}_2\text{O}_{(\text{l})}$
 c) $\text{Ar}_{(\text{g})}$ at 5 atm or $\text{Ar}_{(\text{g})}$ at 0.30 atm

2. Predict the **sign** of the entropy change for the following:

- a) Salt dissolves in water
 b) Solid ammonium dichromate is burned to give a solid and a gas
 c) Saturated calcium acetate solution is mixed with ethanol to form a gel
 d) Cooling nitrogen gas from 80°C to 20°C
 e) Freezing liquid bromine
 f) Evaporating ethanol

+
+
-
-
-
+

3. Does entropy increase or decrease when water freezes? Explain.

decrease

The number of positions that molecules may occupy is limited in the solid

4. Which of the following are always spontaneous? Which are exothermic?

- a) $\Delta G = +$
 b) $\Delta S_{\text{univ}} = +$
 c) $\Delta S_{\text{surr}} = +$; $\Delta S_{\text{sys}} = +$
 d) $\Delta H = -$; $\Delta S = -$

Spontaneous = B, C
 Exothermic = D

5. Given: $\Delta H = +20.5 \text{ kJ}$; $\Delta S = +52 \text{ J/K}$ $\Delta G = 0$ by definition
 Determine the temperature range for which this reaction is spontaneous.

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

$$0 = 20.5 - (0.052T)$$

$$0.052T = 20.5$$

$$T = 394$$

Above 394 K

6. At what temperatures are the following spontaneous? [Ex. all T, high T, etc]

- a) $\Delta H = -$ and $\Delta S = +$

all temp

- b) $\Delta H = -$ and $\Delta S = -$

low temp

- c) $\Delta H = +$ and $\Delta S = +$

high temp

$\Delta H_{soln} = +$ which does not favor solution however. ΔS is positive which does. The

1. When solid potassium iodide is dissolved in water, a cooling of the mixture occurs because the solution process is endothermic for these substances. Explain, in terms of what happens to the molecules and ions, why this mixing occurs spontaneously?

entropy change allows greater disorder of the universe

2. Will the entropy change for each of the following be positive or negative?

(a) Moisture condenses on the outside of a cold glass. $(-)$

(b) Raindrops form in a cloud. $(-)$

(c) Gasoline vaporizes in the carburetor of an automobile engine. $(+)$

(d) Air is pumped into a tire. $(+)$ more molecules more positions more disorder

(e) Frost forms on the windshield of your car. $(-)$

(f) Sugar dissolves in coffee. $(+)$

3. In animated cartoons, visual effects are often created (for amusement) that show events that ordinarily don't occur in real life because they are accompanied by huge entropy decreases. Can you think of an example of this? Explain why there is an entropy decrease in your example. (Hint: The coyote and roadrunner cartoons are excellent references for this question.)

4. Predict the algebraic sign of the entropy change for the following reactions?

(a) $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{PCl}_5(\text{g})$ $(-)$

(b) $\text{SO}_2(\text{g}) + \text{CaO}(\text{s}) \rightarrow \text{CaSO}_3(\text{s})$ $(-)$

(c) $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{CO}_3(\text{aq})$ $(-)$

(d) $\text{Ni}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{NiCl}_2(\text{aq})$ $(+)$

5. Calculate the entropy change in J/K for each of the following reactions.

(a) $\text{CaO}(\text{s}) + 2 \text{HCl}(\text{g}) \rightarrow \text{CaCl}_2(\text{s}) + \text{H}_2\text{O}(\text{l})$
 $[108.5 + 20] - [40 + (2 \cdot 187)]$
 $128.5 - 414 = -285.5 \text{ J/K}$

(b) $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$
 $(229.5) - [(219) + (131)]$
 $229.5 - 350 = -120.5 \text{ J/K/mol}$

6. Calculate S° (in J/K) for the following reaction.

(a) $\text{H}_2\text{O}(\text{l}) + \text{SO}_3(\text{g}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$
 $157 - [(70 + 257)] = -170 \text{ J/K}$

(b) $2 \text{KCl}(\text{s}) + \text{H}_2\text{SO}_4(\text{l}) \rightarrow \text{K}_2\text{SO}_4(\text{s}) + 2 \text{HCl}(\text{g})$
 $[2(201.87) + (176)] - [(2 \cdot 83) + (157)] = 550 - 323 = 227 \text{ J/K}$

(c) $\text{C}_2\text{H}_4 + \text{H}_2\text{O}(\text{g}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{l})$
 $(161) - (219 + 189) = 161 - 408 = -247 \text{ J/K}$