1. 3.14 mol of $H_2(g)$ initially at 420 °C and 69 atm undergoes a reversible cyclic process for which $q = -67$ J. What is the ΔS for the process?

   Entropy is a state function:

   $$\boxed{\Delta S = 0}$$

2. Consider a system of 4 distinguishable particles with total energy of 3. The allowed energy levels are $\varepsilon = 0, 1, 3, 6$.

   (a) How many macrostates are possible?

   2 macrostates. $(0, 0, 0, 3)$ and $(0, 1, 1, 1)$

   (b) How many microstates are possible for each macrostate?

   4 and 4 respectively

   (c) If the temperature goes up, which will increase (circle all)

   - ☐ the spacing between energy levels
   - ■ the number of accessible energy levels
   - ☐ the number of possible microstates
   - ☐ the number of possible macrostates

   (d) Circle all the possible values of the next energy level ε

   ☐ 7 ☐ 8 ☐ 9 ■ 10 ■ 11 ■ 12 ■ 13

3. Rank the first four halogens in order of increasing standard molar entropy.

   $$I_2(s) < Br_2(l) < F_2(g) < Cl_2(g)$$

4. Write =, <, >, or X (for cannot be determined). Formaldehyde is CH_2O

Compound	Melting Point	Boiling Point
Formaldehyde	181 K	254 K
Boron tribromide	227 K	364 K

   (a) $S_{\text{formaldehyde}}$ at 0 K ____>____ $S_{\text{boron tribromide}}$ at 0 K

   (b) $S_{\text{formaldehyde}}$ at 298 K ____>____ $S_{\text{boron tribromide}}$ at 298 K

(c) $S_{\text{formaldehyde}}$ at 398 K ___<___ $S_{\text{boron tribromide}}$ at 398 K

5. Which molecule has the highest residual entropy?

☐ SiO_2 ☐ CS_2 ■ N_2O

6. Rank the following molecules in order of increasing residual entropy.

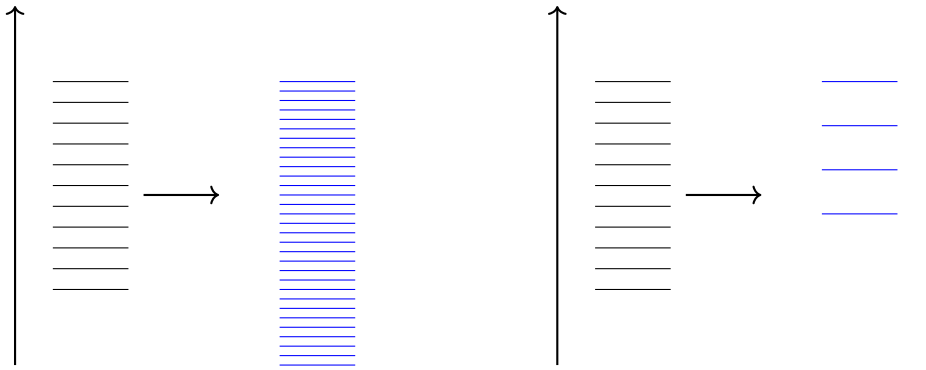
HF HCN C_2H_2

$C_2H_2 < HF < HCN$

7. Fill in the table with =, +, −, or X (for cannot be determined).

Reaction	ΔH°	ΔS°
Water vapor condensing	-	-
$H_2(g) \longrightarrow 2\,H(g)$	+	+
$CH_3OH(l) + \frac{3}{2}\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(g)$	-	+

8. Suppose there is a reaction that is both exothermic and spontaneous. Draw below what would happen to the energy level diagram. What if it was endothermic and non-spontaneous?



Reactants Products Reactants Products

9. An increase in accessible microstates can result from either:

☐ Decreased energy level spacing ☐ Increased thermal energy ☐ Other

For each process, indicate why the entropy increases.

(a) Isothermal expansion

Decreased energy level spacing

(b) Isochoric heating

Increased thermal energy

(c) Isochoric compression

Increased thermal energy

(d) Isochoric isothermal addition of moles

Other

Homework Problem 16

1. (a) Consider a system of 5 distinguishable particles with total energy 20. Draw all available macrostates based on the energy level diagram below. Use as many figures as you need, not all of them may be required.
   (b) Indicate the macrostate with exactly 5 microstates. For the other macrostates, indicate if they have more or less than 5 microstates.