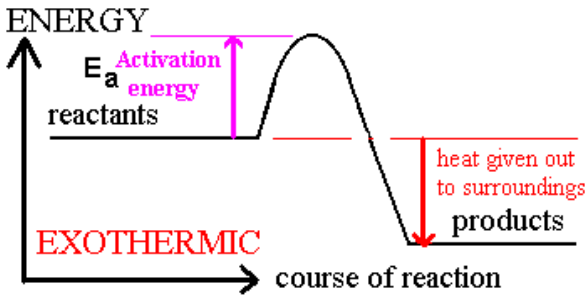
SAMPLE EXERCISES *max S* vs. *min H* **ANSWER KEY**

PREDICT WHICH DIRECTION maximum ENTROPY (S) & minimum ENTHALPY (H) PREFER IN THE FOLLOWING REVERSIBLE REACTIONS ("at equilibrium").
BE SURE TO JUSTIFY YOUR CHOICE WITH A CLEAR REASON FOR min. H and at least two reasons (or the most you can find) for max S IN EACH CASE!

1. $2H_2(g) + O_2(g) \rightleftarrows 2H_2O(g) + 483kJ$

"Maximum Entropy favours reactants"
← max S
More Moles
More Variety of Molecules

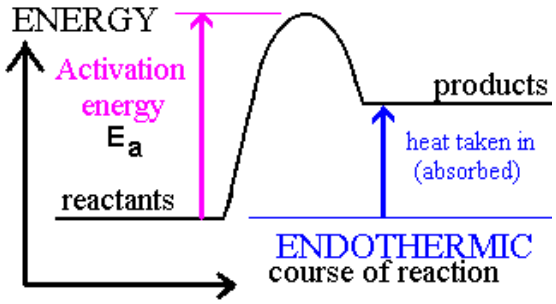
"Minimum Enthalpy favours products"
→ min H
EXOTHERMIC



2. $H_2O(l) + 44kJ \rightleftarrows H_2O(g)$

"Minimum Enthalpy favours reactants"
← Min H
ENDOTHERMIC

"Maximum Entropy favours products"
→max S
Gas phase has more entropy than liquid phase
Temperature Increases (boiling)



3. $C_3H_8(g) + 104kJ \rightleftarrows 3C(s) + 4H_2(g)$

← Min H
ENDOTHERMIC

→max S
More Moles
More phases of matter
More variety of molecules
More moles in random order (there is more moles of the random gas phase)

4. $NH_4NO_3(s)$ + kJ ⇄ $NH_4^+(aq)$ + $NO_3^-(aq)$

← **Min H**

ENDOTHERMIC

→**max S**

More Moles

More Variety

Aqueous ions have more entropy than solid compound

More moles of the random order (Aq ions vs. Solid)

5. $C_2H_2(g)$ + 5/2 $O_2(g)$ ⇄ $2CO_2(g)$ + $H_2O(g)$ + 1260kJ

← **max S**

More Moles (by ½ mole)

→ **min H**

EXOTHERMIC

No other reason can be found.

If I am desperate for a second reason, I can always use:

"The Second Law of Thermodynamics"

Which states that energy cannot be used to do work, without a loss to entropy.

(reading this reaction in reverse, which is the direction that entropy prefers, the energy is put INTO the reaction, so entropy will result, if this reaction goes from right to left)

6. $SO_2(g)$ + 1/2 $O_2(g)$ ⇄ $SO_3(g)$ +100kJ

← **max S**

More Moles

More Variety of Molecules

→ **min H**

EXOTHERMIC

7. 2HCl(g) + kJ ⇄ $H_2(g)$ + $Cl_2(g)$

← **Min H**

ENDOTHERMIC

→**max S**

EQUAL Moles, hoewever, more variety of molecules

"The Second Law of Thermodynamics"

8. Mg(s) + $2H^+(aq)$ ⇄ $Mg^{2+}(aq)$ + $H_2(g)$ + kJ

← **max S**

More Moles

"The Second Law of Thermodynamics"

→ **min H**

EXOTHERMIC

9. $2KClO_3(s)$ + kJ ⇄ 2KCl(s) + $3O_2(g)$

← **Min H**

ENDOTHERMIC

→**max S**

More Moles

More Variety of Molecules

More phases of matter

More moles of a random phase

10. NH_3 + HCl ⇄ NH_4Cl + 180 kJ

← **max S**

More Moles

More Variety of Molecules

→ **min H**

EXOTHERMIC

11. $H_2O_2(l)$ + kJ ⇄ $H_2O(l)$ + 1/2 $O_2(g)$

← **Min H** →**max S**

ENDOTHERMIC

More Moles

More Phases of matter

More random phase on the product side (there is a gas now)

12. $2H_2(g)$ + $O_2(g)$ ⇄ $2H_2O(g)$ + kJ

← **max S** → **min H**

More Moles ***EXOTHERMIC***

More Variety of Molecules

13. $ZnCl_2(s)$ + kJ ⇄ $Zn^{2+}(aq)$ + $2Cl^-(aq)$

← **Min H** →**max S**

ENDOTHERMIC

More Moles

Ions versus atoms (Aq vs. S)

More variety of particles