Gibb's Free Energy

1. Methanol is used as a rocket fuel for the following chemical reaction:
   $CH_3OH\ (l) + 3/2\ O_2\ (g) \rightarrow H_2O\ (g) + CO_2\ (g)$

   a) Predict the sign of ΔS for the above reaction and explain your answer with sound reasoning.

   +ΔS : # of gas particles increases
   1½ → 2 particles

   state change liquid + gas → gas
   (gas is more disordered)

   b) Predict the sign of ΔH for the above reaction (knowing that it is combustion) and explain your answer with sound reasoning.

   −ΔH : combustion is exothermic
   ∴ ΔH products < ΔH reactants

   c) Is the sign of ΔG temperature dependent in this reaction? Explain your answer.

   No – since enthalpy and entropy both agree that the reaction should happen, this reaction will be spontaneous at all temps.

2. Predict the signs for ΔG, ΔH and ΔS for the following situations and explain your answer.
   a) The vaporization of water above 100 °C.

   +ΔS – increase in disorder as liquid → gas
   +ΔH – liquid has to absorb heat to become gas
   −ΔG – vaporization is spontaneous at T > 100°C

   b) Does ΔH or ΔS favour the vaporization process?

   ΔS favours vaporization → increase in disorder

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3. For the reaction CO (g) + H_2O (g) → CO_2 (g) + H_2 (g)

   ΔH = -41.2 kJ and ΔS = -135 J/K

   a) Calculate ΔG at room temperature, 298 K.

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

$\Delta G = -41.2\ kJ - 298(-.135\ kJ)$

$\Delta G = -0.97\ kJ$

   b) Calculate ΔG at 700K, assuming ΔH and ΔS are not affected by temperature.

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

$\Delta G = -41.2\ kJ - 700(-0.135)$

$\Delta G = 53.3\ kJ$

   c) Does raising the temperature favour this reaction, as written?

No - higher temp changes the reaction from spontaneous to non-spontaneous

   d) Which factor, entropy or enthalpy, favours this reaction at high and low temperature?

Enthalpy → it is negative (favourable)
entropy is negative which isn't favourable.

4. Calculate the boiling point for the reaction: BCl_3 (l) → BCl_3 (g)

	ΔH° (kJ/mol)	ΔS° (J/mol·K)
BCl_3 (l) initial	-418	209
BCl_3 (g) final	-395	290

$\Delta H = 23\ kJ$ $\Delta S = 81\ J/mol\ K$

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

→ $0 = 23 - T(.081)$

0 is the tipping point

$23 = T(.081)$

$T = 283.95\ K = \boxed{10.95\ ^\circ C}$