Quiz 3.3 – Gibbs Energy and T

Name: _____

The Equilibrium Temperature

Consider the Haber-Bosch process: $3\,H_2(g) + N_2(g) \rightleftharpoons 2\,NH_3(g)$

At $298\ K$ this reaction has $\Delta G^{\ominus} = -32.90\frac{kJ}{mol}$, $\Delta H^{\ominus} = -92.22\frac{kJ}{mol}$, and $\Delta S^{\ominus} = -198.76\frac{J}{mol\ K}$

In CHEM 1220 you learned that $\Delta G = \Delta H - T\Delta S$, and used this formula to calculate the equilibrium temperature: $T = \frac{\Delta H}{\Delta S}$. Use this formula to find the equilibrium temperature.

That formula relies on the assumption that ΔH and ΔS are both independent of temperature, which is only a good approximation over very small temperature ranges. Use Kirchoff's law to find ΔH and use $\Delta S(T_2) = \Delta S(T_1) + \int_{T_1}^{T_2} \frac{\Delta C_p}{T} \mathrm{d}T$ to find ΔS at the equilibrium temperature you calculated above

Use these values of ΔH and ΔS to find ΔG at the equilibrium temperature you calculated above. Is the system really at equilibrium?

Find the true equilibrium temperature using the Gibbs-Helmholtz equation: $\left(\frac{\mathrm{d}\left({}^{\Delta G}/_{T}\right)}{\mathrm{d}T}\right)_p = -\frac{\Delta H}{T^2}$

Find ΔH and ΔS at that temperature, and confirm that the system is at equilibrium at that temperature

The New Colossus

By Emma Lazarus

Not like the brazen giant of Greek fame,
With conquering limbs astride from land to land;
Here at our sea-washed, sunset gates shall stand
A mighty woman with a torch, whose flame
Is the imprisoned lightning, and her name
Mother of Exiles. From her beacon-hand
Glows world-wide welcome; her mild eyes command
The air-bridged harbor that twin cities frame.
"Keep, ancient lands, your storied pomp!" cries she
With silent lips. "Give me your tired, your poor,
Your huddled masses yearning to breathe free,
The wretched refuse of your teeming shore.
Send these, the homeless, tempest-tost to me,
I lift my lamp beside the golden door!"