Unit 4: AP Free Response Practice #2 [2017 #2, shortened, 5 points]

2. Answer the following questions about the isomers fulminic acid and isocyanic acid.

Fulminic acid can convert to isocyanic acid according to the equation below.

$$HCNO(g) \rightleftarrows HNCO(g)$$

fulminic acid *isocyanic acid*

Fulminic Acid	Isocyanic Acid
H—C≡N—Ö:	H—N̈=C=Ö:

a. Using the Lewis electron-dot diagrams of fulminic acid and isocyanic acid shown in the boxes above and the table of average bond enthalpies below, determine the value of ΔH° for the reaction of HCNO(g) to form HNCO(g). [*2 points*]

Bond	Enthalpy (kJ/mol)	Bond	Enthalpy (kJ/mol)	Bond	Enthalpy (kJ/mol)
N–O	201	C=N	615	H–C	413
C=O	745	C≡N	891	H–N	391

b. A student claims that ΔS° for the reaction is close to zero. Explain why the student's claim is accurate. [*1 point*]

c. Which species, fulminic acid (HCNO) or isocyanic acid (HNCO), is present in high concentration at equilibrium at 298 K? Justify your answer in terms of the thermodynamic favorability and the equilibrium constant. [*2 points*]

a.) $\Delta H^\circ_{rxn} = \Sigma BE(re) - \Sigma BE(prod)$

$= [1(C-H) + 1(C\equiv N) + 1(N-O)] - [1(H-N) + 1(N=C) + 1(C=O)]$

$= [413 + 891 + 201] - [391 + 615 + 745]$

$= 1505 - 1751 = \boxed{-246\ kJ/mol_{rxn}}$

b.) $\Delta S^\circ_{rxn} \approx 0$ b/c there is no change in # of particles or state of matter during the rxn - 1 gas molecule becomes 1 different gas molecule.

c.) Since $\Delta S^\circ_{rxn} \approx 0$, $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \approx \Delta H^\circ = -246\ kJ/mol_{rxn}$, $-\Delta G^\circ$ indicates the forward rxn is thermodynamically favorable, so $K > 1$, which means isocyanic acid (HNCO, the product) will be present in higher concentration at equilibrium.