Exam #2: 4-2-2020: **Please show all work for credit**, Don't Panic

Name: ______________________

1. The decarboxylation of pyruvic acid occurs via the following reaction:

$$CH_3COCOOH(l) \longrightarrow CH_3CHO(g) + CO_2(g)$$

Given the following thermodynamic data

$$\Delta_f H(25\ C)_{CH_3COCOOH} = -584\ kJ\ mol^{-1} \quad \Delta_f G(25\ C)_{CH_3COCOOH} = -463\ kJ\ mol^{-1}$$
$$\Delta_f H(25\ C)_{CH_3CHO} = -166\ kJ\ mol^{-1} \quad \Delta_f G(25\ C)_{CH_3CHO} = -133\ kJ\ mol^{-1}$$
$$\Delta_f H(25\ C)_{CO_2} = -394\ kJ\ mol^{-1} \quad \Delta_f G(25\ C)_{CO_2} = -394\ kJ\ mol^{-1}$$

a. Calculate ΔG°_{rxn}. Is this reaction spontaneous under standard state conditions? Justify your answer.

$\Delta G^{\circ}_{rxn} = \left[\left(-394\ \frac{kJ}{mol}\right) + \left(-133\ \frac{kJ}{mol}\right)\right] - \left[-463\ \frac{kJ}{mol}\right] = -64\ kJ/mol$

$\Delta H^{\circ}_{rxn} = \left[\left(-394\ \frac{kJ}{mol}\right) + \left(-166\ \frac{kJ}{mol}\right)\right] - \left[-584\ \frac{kJ}{mol}\right] = 24\ kJ/mol$

the reaction is spontaneous under standard conditions because $\Delta G < 0$.

b. Calculate the equilibrium constant, K_P, for this reaction at 80.0 K.

$K_p = e^{\left(\frac{-64\ kJ/mol}{(0.0083)(298K)}\right)}$

$= 6.045 \times 10^{-12}$

$\ln\left(\frac{K_2}{K_1}\right) = \frac{-\Delta H^{\circ}_{rxn}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$\ln\left(\frac{K_2}{6.045 \times 10^{-12}}\right) = \left(-\frac{24\ kJ/mol}{0.008314\ kJ/mol}\right)\left(\frac{1}{80} - \frac{1}{298}\right)$

$K_2 = 2.077 \times 10^{-23}$

c. At the lower temperature, does the reaction favor the reactants or the products?

at low T the rxn favors products