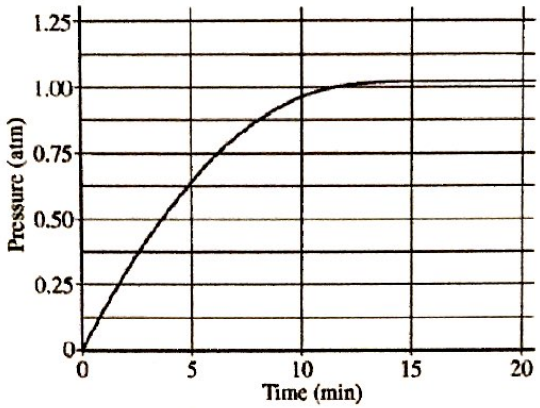
FR Practice #4 (2014 #4, 4 points)

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

4. When heated, calcium carbonate decomposes according to the equation above. In a study of the decomposition of calcium carbonate, a student added a 50.0 g sample of powdered $CaCO_3(s)$ to a 1.00 L rigid container. The student sealed the container, pumped out all the gases, then heated the container in an oven at 1100 K. As the container was heated, the total pressure of the $CO_2(g)$ in the container was measured over time. The data are plotted in the graph below.



The student repeated the experiment, but this time the student used a 100.0 g sample of powdered $CaCO_3(s)$. In this experiment, the final pressure in the container was 1.04 atm, which was the same final pressure as in the first experiment.

a. Calculate the number of moles of $CO_2(g)$ present in the container after 20 minutes of heating. (1 point)
b. The student claimed that the final pressure in the container in each experiment became constant because all of the $CaCO_3(s)$ had decomposed. Based on the data in the experiments, do you agree with this claim? Explain. (1 point)
c. After 20 minutes some $CO_2(g)$ was injected into the container, initially raising the pressure to 1.5 atm. Would the final pressure inside the container be less than, greater than, or equal to 1.04 atm? Explain your reasoning. (1 point)
d. Are there sufficient data obtained in the experiments to determine the value of the equilibrium constant, K_p, for the decomposition of $CaCO_3(s)$ at 1100 K? Justify your answer. (1 point)

(a) $n = \frac{PV}{RT} = \frac{(1.04\ atm)(1.00\ L)}{(0.08206\ \frac{L \cdot atm}{mol \cdot K})(1100\ K)} = 0.012\ mol\ CO_2$

(b) Do not agree: in two different experiments, w/ different starting amounts of $CaCO_3(s)$ (50.0 g vs 100.0 g), the same final pressure of 1.04 atm was reached. Since increasing the amount of reactant did not produce more product, all of the $CaCO_3$ did not react - instead, equilibrium was reached.

(c.) $P_{final} = 1.04$ atm, b/c equilibrium was reached in both experiments @ 1.04 atm, so increasing the amount of $CO_{2(g)}$ (the only gas present) will cause the rxn to shift left until the amount of $CO_{2(g)}$ is decreased + pressure is once again 1.04 atm.

(d.) Yes, since $K_p = P_{CO_2} = 1.04$