



## AP<sup>®</sup> Chemistry 2002 Sample Student Responses

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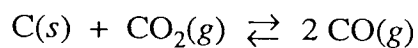
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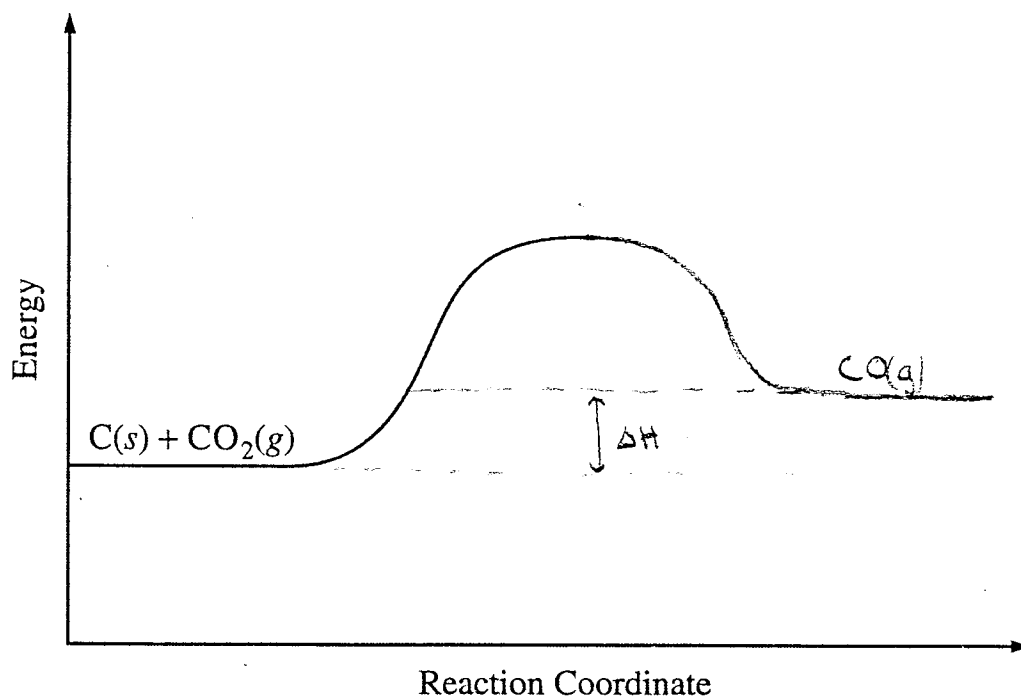
8. Carbon (graphite), carbon dioxide, and carbon monoxide form an equilibrium mixture, as represented by the equation above.

(a) Predict the sign for the change in entropy,  $\Delta S$ , for the reaction. Justify your prediction.

(b) In the table below are data that show the percent of CO in the equilibrium mixture at two different temperatures. Predict the sign for the change in enthalpy,  $\Delta H$ , for the reaction. Justify your prediction.

Temperature	% CO
700°C	60
850°C	94

(c) Appropriately complete the potential energy diagram for the reaction by finishing the curve on the graph below. Also, clearly indicate  $\Delta H$  for the reaction on the graph.



(d) If the initial amount of C(s) were doubled, what would be the effect on the percent of CO in the equilibrium mixture? Justify your answer.

a)  $\Delta S > 0$  for this reaction because the reaction is going from one solid and one gas molecule to two gas molecules. Since the positional probability for gas molecules is much greater than that for solids, the entropy will increase in the forward reaction.

b)  $\Delta H > 0$  for this reaction because since the % CO increases with temperature, the equilibrium is shifted right when heat is added, showing that heat is a reactant.

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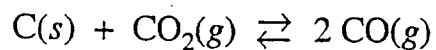
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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

d) If the initial amount of  $\text{C(s)}$  were doubled there would be no effect on the %  $\text{CO}$  in the equilibrium mixture because looking at the equilibrium constant  $K = \frac{(\text{CO})^2}{(\text{CO}_2)}$ , carbon is not a factor since it is a solid. Therefore doubling the initial amount of  $\text{C(s)}$  would not produce a change in the equilibrium mixture.

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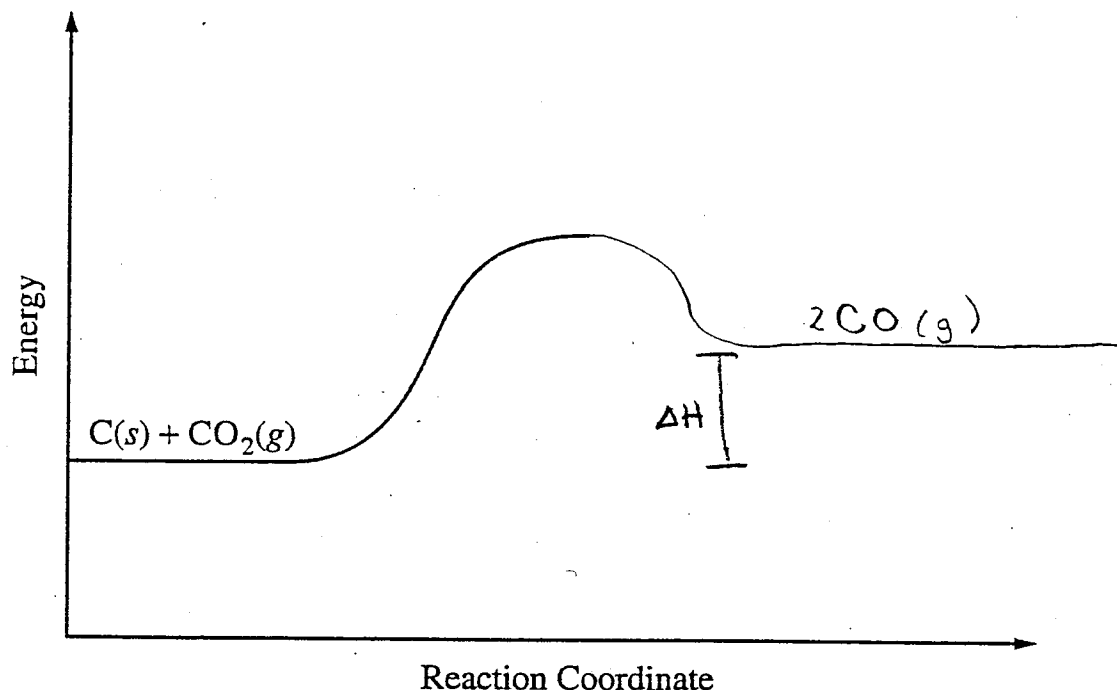
8. Carbon (graphite), carbon dioxide, and carbon monoxide form an equilibrium mixture, as represented by the equation above.

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(d) If the initial amount of C(s) were doubled, what would be the effect on the percent of CO in the equilibrium mixture? Justify your answer.

a. The  $\Delta S$  would be positive, because the reactants are 1 mole of gas and 1 mole of solid, the product is 2 moles of gas. Entropy is the measurement of disorder, and gas has a higher entropy than solids.

b. The  $\Delta H$  is positive and the reaction is endothermic. As heat is added the amount of CO increases. According to Le Chatelier's principle, as the temperature increases when heat is a reactant, the reaction will

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proceed to the right, producing more products.

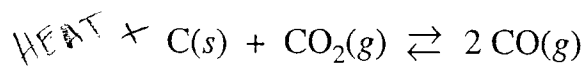
c. see graph

d. If  $C$  were doubled, the percent of  $CO$  would increase.

$C$  is a reactant and  $CO$  is a product. According to Le Chatelier's principle, when the concentration of a reactant is increased, the reaction proceeds to the right, producing more products.

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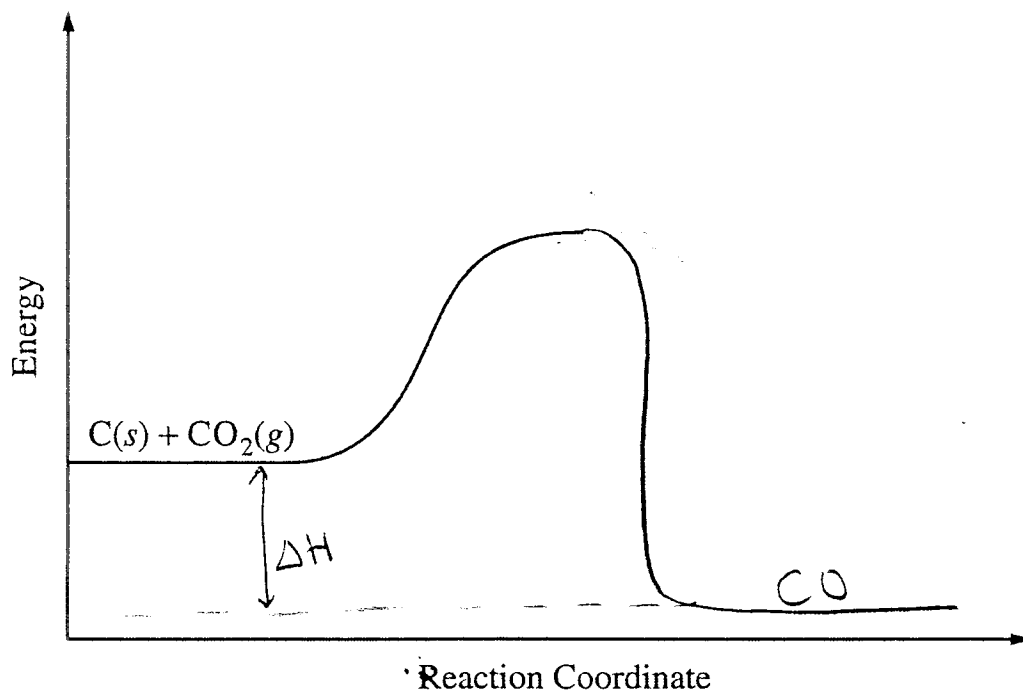
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(c) Appropriately complete the potential energy diagram for the reaction by finishing the curve on the graph below. Also, clearly indicate  $\Delta H$  for the reaction on the graph.



(d) If the initial amount of  $\text{C}(s)$  were doubled, what would be the effect on the percent of CO in the equilibrium mixture? Justify your answer.

(a) Since  $\Delta n_{\text{gaseous}}$  is  $2 - 1 = +1$ ,  $\Delta S$  will be positive.

(b) Increasing the temperature causes the equilibrium to shift in favor of the products side so heat must be on the reactants side. This indicates that the reaction is endothermic so  $\Delta H$  is positive.

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(d) Increasing the amount of  $C_{(s)}$  would cause the equilibrium to shift in favor of the products side and the percent of CO in the mixture would increase.