AP® Chemistry
2002 Sample Student Responses

These materials were produced by Educational Testing Service® (ETS®), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 4,200 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT®, and the Advanced Placement Program® (AP®). The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

$$C(s) + CO_2(g) \rightleftarrows 2\,CO(g)$$

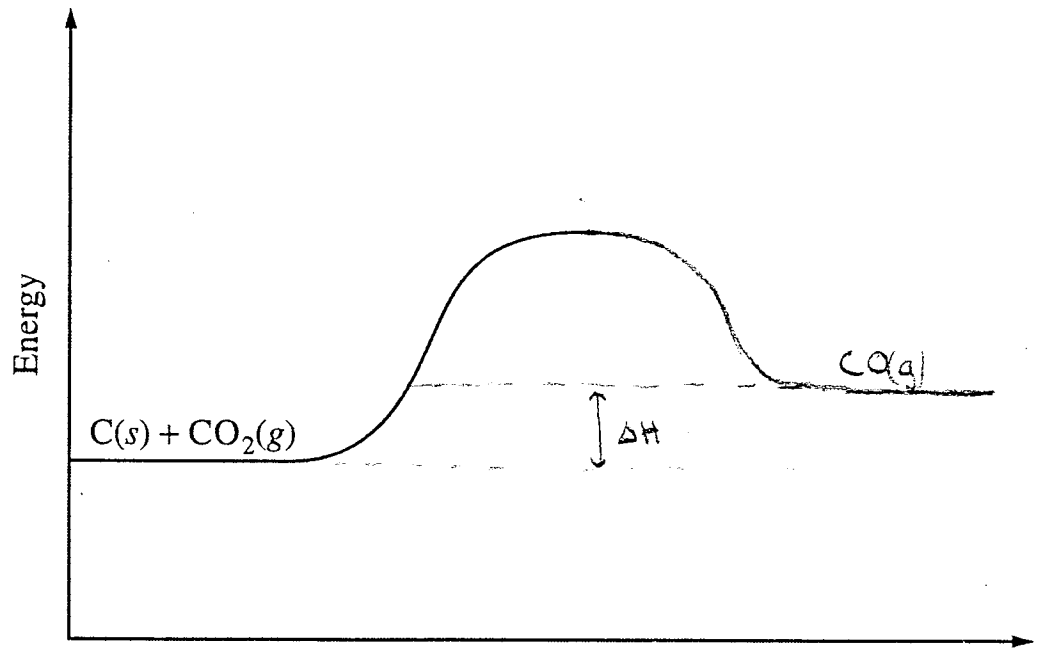
8. Carbon (graphite), carbon dioxide, and carbon monoxide form an equilibrium mixture, as represented by the equation above.

(a) Predict the sign for the change in entropy, ΔS, 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, ΔH, 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 ΔH 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.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

d) If the initial amount of Cu were doubled there would be no effect on the % CO in the equilibrium mixture because looking at the equilibrium constant $K = \frac{[CO]^2}{[O_2]}$, carbon is not a factor since it is a solid. Therefore, doubling the initial amount of Cu would not produce a change in the equilibrium mixture.

B B B B B B B B B B B B B B

8B1

$$C(s) + CO_2(g) \rightleftarrows 2\,CO(g)$$

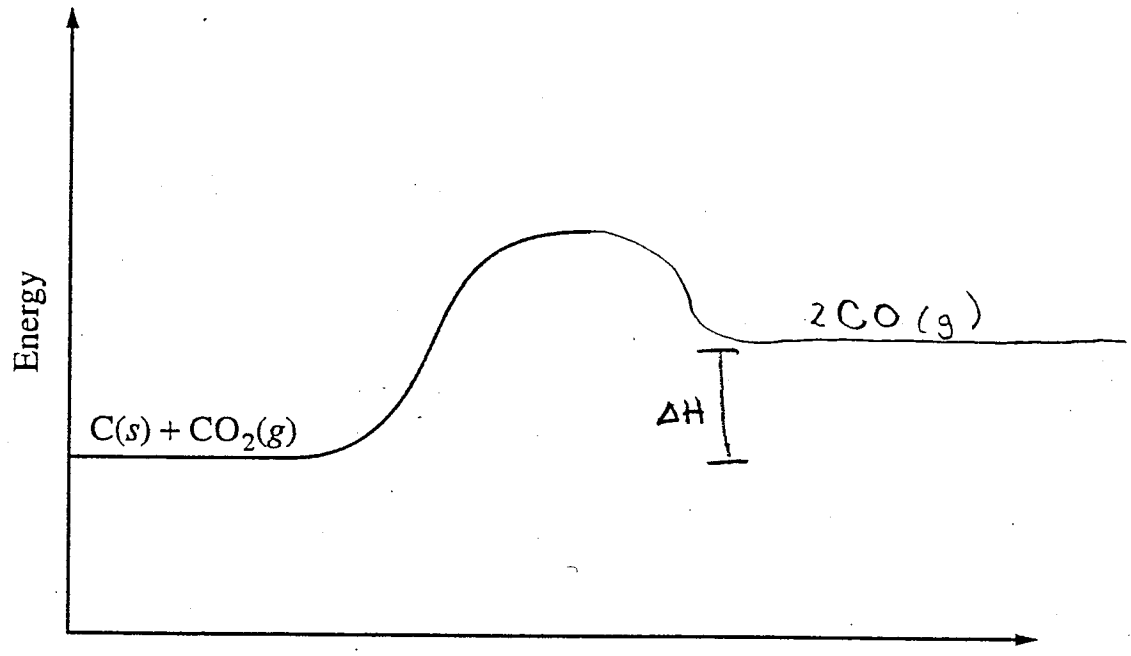
8. Carbon (graphite), carbon dioxide, and carbon monoxide form an equilibrium mixture, as represented by the equation above.

(a) Predict the sign for the change in entropy, ΔS, 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, ΔH, 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 ΔH 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. The ΔS 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 ΔH 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

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

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.

B B B B B B B B B B B B B B 8C.1

$$\text{HEAT} + C(s) + CO_2(g) \rightleftarrows 2\,CO(g)$$

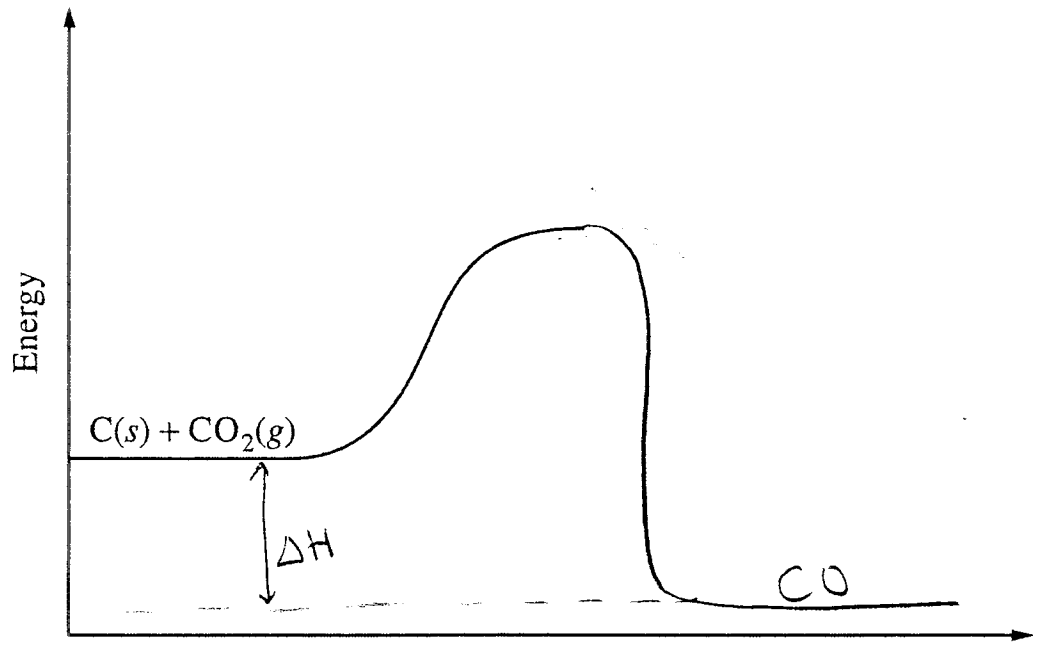
8. Carbon (graphite), carbon dioxide, and carbon monoxide form an equilibrium mixture, as represented by the equation above.

(a) Predict the sign for the change in entropy, ΔS, 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, ΔH, 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 ΔH 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) Since $\Delta n_{gaseous}$ is $2-1=+1$, ΔS 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 ΔH is positive.

GO ON TO THE NEXT PAGE.

 8C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

(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.