AP® CHEMISTRY
2002 SCORING GUIDELINES

Question 8

Total Score 8 Points

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

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.

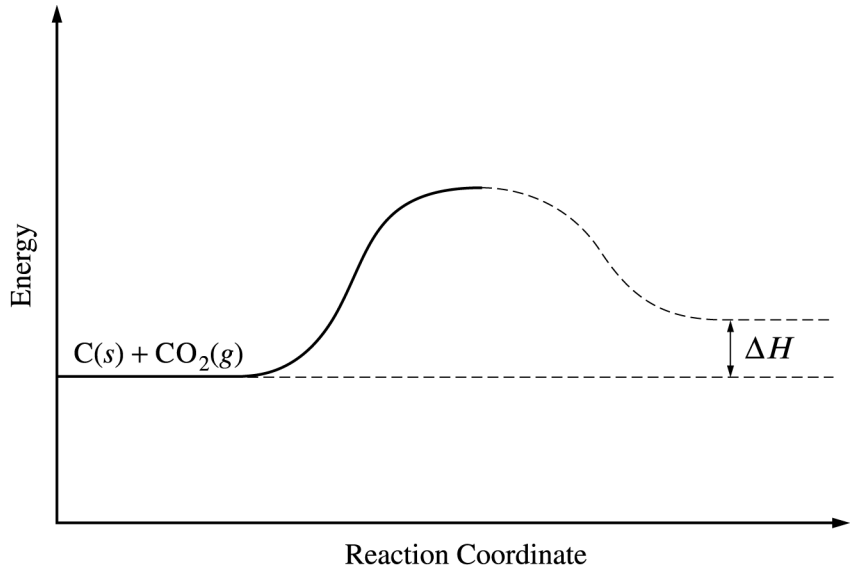
$\Delta S = +$ There is more disorder in a gas than in a solid, so the product is more disordered than the reactants. The change in entropy is therefore positive. **OR** There is 1 mole of gas in the reactants and 2 moles of gas in the product.	1 point earned for indicating that ΔS is positive 1 point earned for explanation

(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

$\Delta H = +$ More CO at the higher temperature indicates that the reaction shifts to the right with increasing temperature. For this to occur, the reaction must be endothermic.	1 point earned for indicating that ΔH is positive 1 point earned for explanation

(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.



1 point earned for completing the graph according to the information in part (b) 1 point earned for appropriately labeling ΔH_{rxn} for the reaction as drawn

(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.

An increase in the amount of $C(s)$ has no effect. Solids do not appear in the equilibrium expression, so adding more $C(s)$ will not affect the percent of CO in the equilibrium mixture.	1 point earned for indicating no effect 1 point earned for explanation

Note: Since the question asks about "percent of CO" a student might think of % by mass or % by mole. Adding carbon will not shift the equilibrium, so P_{CO} and P_{CO_2} stay the same. The % CO then decreases, because now there are more total moles in the system: % CO = $n_{CO}/(n_{CO} + n_{CO_2} + n_C)$
As n_C is raised, the denominator increases, and % CO decreases.