TABLE 19.4 Effect of Temperature on the Spontaneity of Reactions

ΔH	ΔS	$-T\Delta S$	$\Delta G = \Delta H - T\Delta S$	Reaction Characteristics	Example
−	+	−	Always negative	Spontaneous at all temperatures	$2O_3(g) \longrightarrow 3O_2(g)$
+	−	+	Always positive	Nonspontaneous at all temperatures; reverse reaction always spontaneous	$3O_2(g) \longrightarrow 2O_3(g)$
−	−	+	Negative at low T; positive at high T	Spontaneous at low T; becomes nonspontaneous at high T	$H_2O(l) \longrightarrow H_2O(s)$
+	+	−	Positive at low T; negative at high T	Nonspontaneous at low T; becomes spontaneous at high T	$H_2O(s) \longrightarrow H_2O(l)$

For a certain chemical reaction, $\Delta H° = -35.4$ kJ and $\Delta S° = -85.5$ J/K. **(a)** Is the reaction exothermic or endothermic? **(b)** Does the reaction lead to an increase or decrease in the disorder of the system? **(c)** Calculate $\Delta G°$ for the reaction at 298 K. **(d)** Is the reaction spontaneous at 298 K?

A certain reaction has $\Delta H° = -19.5$ kJ and $\Delta S° = +42.7$ J/K. **(a)** Is the reaction exothermic or endothermic? **(b)** Does the reaction lead to an increase or decrease in the disorder of the system? **(c)** Calculate $\Delta G°$ for the reaction at 298 K. **(d)** Is the reaction spontaneous at 298 K?

Classify each of the following reactions as one of the four possible types summarized in Table 19.4:

(a) $N_2(g) + 3F_2(g) \longrightarrow 2NF_3(g)$
$\Delta H° = -249$ kJ; $\Delta S = -278$ J/K

(b) $N_2(g) + 3Cl_2(g) \longrightarrow 2NCl_3(g)$
$\Delta H° = 460$ kJ; $\Delta S° = -275$ J/K

(c) $N_2F_4(g) \longrightarrow 2NF_2(g)$ $\Delta H° = 85$ kJ; $\Delta S° = 198$ J/K

From the values given for $\Delta H°$ and $\Delta S°$, calculate $\Delta G°$ for each of the following reactions at 298 K. If the reaction is not spontaneous under standard conditions at 298 K, at what temperature (if any) would the reaction become spontaneous?

(a) $2PbS(s) + 3O_2(g) \longrightarrow 2PbO(s) + 2SO_2(g)$
$\Delta H° = -844$ kJ; $\Delta S° = -165$ J/K

(b) $2POCl_3(g) \longrightarrow 2PCl_3(g) + O_2(g)$
$\Delta H° = 572$ kJ; $\Delta S° = 179$ J/K