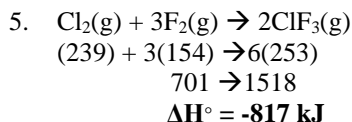
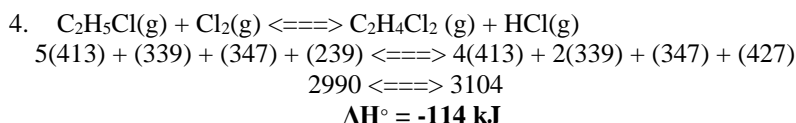
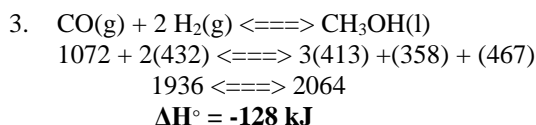
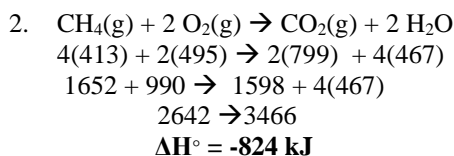
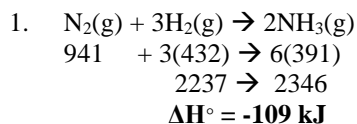
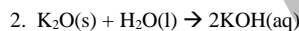


Bond Energy Homework Answers:Calculate the ΔH for each reaction below:**Entropy & Free Energy Homework Answers:**1. Decide for each of the following whether the ΔS° is increasing (+) or decreasing (-).

- a. **increasing** $2 \text{KClO}_3(\text{s}) \rightarrow 2 \text{KCl}(\text{s}) + 3 \text{O}_2(\text{g})$ b. **decreasing** $2\text{Ag}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{AgCl}(\text{s})$
 c. **increasing** $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$ d. **increasing** $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 e. **increasing** $2\text{C}_8\text{H}_{18}(\text{l}) + 25\text{O}_2(\text{g}) \rightarrow 16\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\text{g})$ f. **decreasing** $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$

For each of the following reactions you must solve for each:

- a. ΔH°
 b. ΔS°
 c. ΔG° at 25°C
 d. Is the reaction spontaneous?
 e. At what temperature would the reaction become spontaneous or stop being spontaneous?



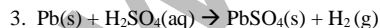
$$\Delta H^\circ = -315 \text{ kJ}$$

$$\Delta S^\circ = -150. \text{ J/K}$$

$$\Delta G^\circ \text{ at } 25^\circ\text{C} = -271 \text{ kJ}$$

Is the reaction spontaneous? Yes, up to 2100 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{K}_2\text{O}(\text{s})$	-361	98
$\text{H}_2\text{O}(\text{l})$	-286	70.
$\text{KOH}(\text{aq})$	-481	9.2



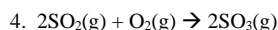
$$\Delta H^\circ = -11 \text{ kJ}$$

$$\Delta S^\circ = 195 \text{ J/K}$$

$$\Delta G^\circ \text{ at } 25^\circ\text{C} = -69 \text{ kJ}$$

Is the reaction spontaneous? Yes, always

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{Pb}(\text{s})$	0	65
$\text{H}_2\text{SO}_4(\text{aq})$	-909	20.
$\text{PbSO}_4(\text{s})$	-920	149
$\text{H}_2(\text{g})$	0	131



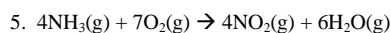
$$\Delta H^\circ = -198 \text{ kJ}$$

$$\Delta S^\circ = -187 \text{ J/K}$$

$$\Delta G^\circ \text{ at } 25^\circ\text{C} = -142 \text{ kJ}$$

Is the reaction spontaneous? Yes, up to 1060 K

Substance	ΔH°_f (kJ/mol)	S° (J/K mol)
$\text{SO}_2(\text{g})$	-297	248
$\text{SO}_3(\text{g})$	-396	257
$\text{O}_2(\text{g})$	0	205



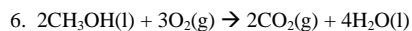
$\Delta H^\circ = -1132 \text{ kJ}$

$\Delta S^\circ = -113 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = -1098 \text{ kJ}$

Is the reaction spontaneous? Yes, up to 10,020 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{NH}_3(\text{g})$	-46	193
$\text{O}_2(\text{g})$	0	205
$\text{NO}_2(\text{g})$	34	240
$\text{H}_2\text{O}(\text{g})$	-242	189



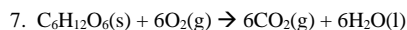
$\Delta H^\circ = -1453 \text{ kJ}$

$\Delta S^\circ = -161 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = -1405 \text{ kJ}$

Is the reaction spontaneous? Yes, up to 9024 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{CH}_3\text{OH}(\text{l})$	-239	127
$\text{O}_2(\text{g})$	0	205
$\text{CO}_2(\text{g})$	-393.5	214
$\text{H}_2\text{O}(\text{l})$	-286	70



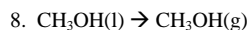
$\Delta H^\circ = -2802 \text{ kJ}$

$\Delta S^\circ = 262 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = -2880 \text{ kJ}$

Is the reaction spontaneous? Yes, always

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$	-1275	212
$\text{O}_2(\text{g})$	0	205
$\text{CO}_2(\text{g})$	-393.5	214
$\text{H}_2\text{O}(\text{l})$	-286	70



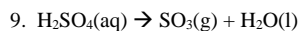
$\Delta H^\circ = 38 \text{ kJ}$

$\Delta S^\circ = 113 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = 4.3 \text{ kJ}$

Is the reaction spontaneous? No, only above 336 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{CH}_3\text{OH}(\text{l})$	-239	127
$\text{CH}_3\text{OH}(\text{g})$	-201	240



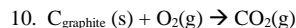
$\Delta H^\circ = 227 \text{ kJ}$

$\Delta S^\circ = 307 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = 136 \text{ kJ}$

Is the reaction spontaneous? No, only above 739 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{H}_2\text{SO}_4(\text{aq})$	-909	20
$\text{SO}_3(\text{g})$	-396	257
$\text{H}_2\text{O}(\text{l})$	-286	70



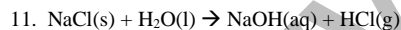
$\Delta H^\circ = -393.5 \text{ kJ}$

$\Delta S^\circ = 3 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = -394 \text{ kJ}$

Is the reaction spontaneous? Yes, always

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{C}_{\text{graphite}}(\text{s})$	0	6
$\text{O}_2(\text{g})$	0	205
$\text{CO}_2(\text{g})$	-393.5	214



$\Delta H^\circ = 135 \text{ kJ}$

$\Delta S^\circ = 95 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = 106.7 \text{ kJ}$

Is the reaction spontaneous? No, above 1421 K

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{NaCl}(\text{s})$	-411	72
$\text{H}_2\text{O}(\text{l})$	-286	70
$\text{NaOH}(\text{aq})$	-470	50
$\text{HCl}(\text{g})$	-92	187



$\Delta H^\circ = -321 \text{ kJ}$

$\Delta S^\circ = 476 \text{ J/K}$

$\Delta G^\circ \text{ at } 25^\circ\text{C} = -462 \text{ kJ}$

Is the reaction spontaneous? Yes, always

Substance	ΔH°_f (kJ/mol)	S° (J/mol K)
$\text{Sn}(\text{s})$	0	52
$\text{HNO}_3(\text{l})$	-174	156
$\text{SnO}_2(\text{s})$	-581	52
$\text{NO}_2(\text{g})$	34	240
$\text{H}_2\text{O}(\text{l})$	-286	70