

Name:

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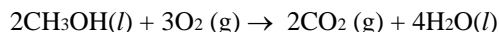
Period:

Seat #:

Show all work. Complete the following on binder paper and BOX your final answers.

[1] Using enthalpies of formation (Appendix Four), calculate  $\Delta H^\circ$  for the following reaction at  $25^\circ\text{C}$ . Also calculate  $\Delta S^\circ$  for this reaction from standard entropies at  $25^\circ\text{C}$ . Use these values to calculate  $\Delta G^\circ$  for the reaction at this temperature.

**-1453.2 KJ, -162 KJ, -1404.9 KJ**



[2] The free energy of formation of one mole of compound refers to a particular chemical equation. For each of the following, write that equation.

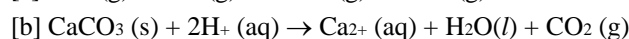
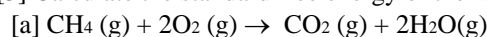
[a]  $\text{NaCl}(s)$

[b]  $\text{HCN}(l)$

[c]  $\text{SO}_2(g)$

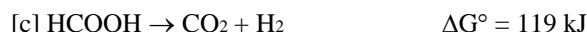
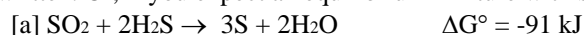
[d]  $\text{PH}_3(g)$

[3] Calculate the standard free energy of the following reactions at  $25^\circ\text{C}$ , using standard free energies of formation.

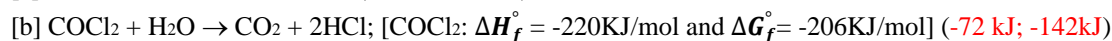
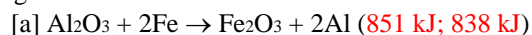


	$\Delta H_f^\circ$	$\Delta G_f^\circ$	$\Delta S^\circ$
<b>Ca<sup>2+</sup></b>	-542.96	-533.04	-55.2

[4] On the basis of  $\Delta G^\circ$  for each of the following reactions, decide whether the reaction is spontaneous or non-spontaneous as written. Or, if you expect an equilibrium mixture with significant amounts of both reactants and products, say so.



[5] Calculate  $\Delta H^\circ$  and  $\Delta G^\circ$  for the following reactions at  $25^\circ\text{C}$ , using thermodynamic data from your books Appendix; interpret the signs of  $\Delta H^\circ$  and  $\Delta G^\circ$ .



[6] Using enthalpies of formation (appendix four), calculate  $\Delta H^\circ$  for the following reactions at  $25^\circ\text{C}$ . Also calculate  $\Delta S^\circ$  for this reaction from standard entropies at  $25^\circ\text{C}$ . Use these values to calculate  $\Delta G^\circ$  for the reaction at this temperature.



[7] The free energy of formation of one mole of compound refers to a particular chemical equation. For each of the following, write that equation.

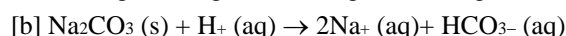
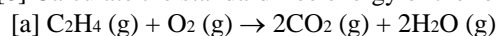
[a]  $\text{CaO}(s)$

[b]  $\text{CH}_3\text{NH}_2(g)$

[c]  $\text{CS}_2(l)$

[d]  $\text{P}_4\text{O}_{10}(s)$

[8] Calculate the standard free energy of the following reactions at  $25^\circ\text{C}$ , using standard free energies of formation from the appendix.



	$\Delta H_f^\circ$	$\Delta G_f^\circ$	$\Delta S^\circ$
<b>HCO<sub>3</sub><sup>-</sup></b>	-691.11	-587.06	95.0

[9] For each of the following reactions, state whether the reaction is spontaneous or non-spontaneous as written or is easily reversible (that is, is a mixture with significant amounts of reactants and products)

- [a]  $\text{HCN} + 2\text{H}_2 \rightarrow \text{CH}_3\text{NH}_2$   $\Delta G^\circ = -92 \text{ kJ}$   
 [b]  $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$   $\Delta G^\circ = 173 \text{ kJ}$   
 [c]  $2\text{NO} + 3\text{H}_2\text{O} \rightarrow 2\text{NH}_3 + \frac{5}{2}\text{O}_2$   $\Delta G^\circ = 479 \text{ kJ}$   
 [d]  $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$   $\Delta G^\circ = -191 \text{ kJ}$   
 [e]  $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$   $\Delta G^\circ = 2.6 \text{ kJ}$

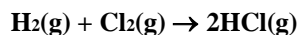
[10] Calculate  $\Delta H^\circ$  and  $\Delta G^\circ$  for the following reactions at  $25^\circ\text{C}$ , using thermodynamic data from Appendix; interpret the signs of  $\Delta H^\circ$  and  $\Delta G^\circ$ .

- [a]  $2\text{PbO} + \text{N}_2 \rightarrow 2\text{Pb} + 2\text{NO}$   
 [b]  $\text{CS}_2 + 2\text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{H}_2\text{S}$ ;  $\text{CS}_2$ :  $\Delta H_f^\circ = 87.9 \text{ kJ}$  and  $\Delta G_f^\circ = 63.6 \text{ kJ}$

[11] Give the expression for the thermodynamic equilibrium constant for each of the following reactions:

- [a]  $\text{CO(g)} + \text{H}_2\text{O(g)} \rightarrow \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$   
 [b]  $\text{Mg(OH)}_2\text{(s)} \rightarrow \text{Mg}^{2+}\text{(aq)} + 2\text{OH}^-\text{(aq)}$   
 [c]  $2\text{Li(s)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{Li}^+\text{(aq)} + 2\text{OH}^-\text{(aq)} + \text{H}_2\text{(g)}$

[12] What is the standard free energy change  $\Delta G^\circ$  at  $25^\circ\text{C}$  for the following reaction? Obtain necessary information from the Appendix:  **$(-190.6 \text{ kJ}, 2.5 \text{E}-33)$**



What is the value of the thermodynamic equilibrium constant  $K$ ?

[13] Calculate the standard free energy change and the equilibrium constant  $K_p$  for the following reaction at  $25^\circ\text{C}$ . See appendix four for data.  **$(-142.2 \text{ kJ}, 8.3 \text{E}24)$**  – From another source  **$\text{CO(g)} + 3\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g}) + \text{H}_2\text{O(g)}$**

[16] Obtain the equilibrium constant  $K_c$  at  $25^\circ\text{C}$  from the free-energy change for the reaction:

	$\Delta H_f^\circ$	$\Delta G_f^\circ$	$\Delta S^\circ$
$\text{Mg(s)} + \text{Cu}^{2+} \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{Cu(s)}$	64.39	64.98	-98.7
<b><math>(-520.99 \text{ kJ}, 1.88 \text{E}91)</math></b>	-461.96	-456.01	-118

[17] What is the standard free-energy change  $\Delta G^\circ$  at  $25^\circ\text{C}$  for the following reaction? Obtain necessary information from Appendix:  **$\text{C(graphite)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$**  Calculate the value of the equilibrium constant  $K$ .

[18] Calculate the standard free energy change and the equilibrium constant  $K_p$  for the following reaction at  $25^\circ\text{C}$ . See appendix for data.  **$\text{CO(g)} + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{OH(g)}$**

[19] Calculate the equilibrium constant  $K_c$  at  $25^\circ\text{C}$  from the free-energy change for the reaction:

	$\Delta H_f^\circ$	$\Delta G_f^\circ$	$\Delta S^\circ$
$\text{Zn(s)} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu(s)}$	64.39	64.98	-98.7
	-152.4	-147.21	-106.5