Dougherty Valley HS Chemistry - AP
Thermodynamics – Extra Practice

Worksheet #4*

Name: **Period:** **Seat#:**

Directions: Any worksheet that is labeled with an * means it is suggested extra practice. We do not always have time to assign every possible worksheet that would be good practice for you to do. You can do this worksheet when you have extra time, when you finish something early, or to help you study for a quiz or a test. If and when you choose to do this Extra Practice worksheet, please do the work on binder paper. You will include this paper stapled into your Rainbow Packet when you turn it in, even if you didn't do any of this. We want to make sure we keep it where it belongs so you can do it later if you want to (or need to). If you did the work on binder paper you can include that in your Rainbow Packet after this worksheet. If we end up with extra class time then portions of this may turn into required work. If that happens you will be told which problems are turned into required. Remember there is tons of other extra practice on the class website…and the entire internet! See me if you need help finding practice on a topic you are struggling with.

Use your reference sheet or an appendix to obtain any needed thermodynamic data for the problems.

1) Using enthalpies of formation calculate ΔH° for the following reaction at 25°C. Also calculate ΔS° for this reaction from standard entropies at 25°C. Use these values to calculate ΔG° for the reaction at this temperature.
$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$ *-1452.1 KJ, -164.8 KJ, -1403.0 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) NaCl (s)
b) HCN (*l*)
c) SO_2 (g)
d) PH_3 (g)

3) Calculate the standard free energy of the following reactions at 25°C, using standard free energies of formation.
a) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ *-800.76*
b) $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$ *-56.1*

4) On the basis of ΔG° for each of the following reactions, decided 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.
a) $SO_2 + 2H_2S \rightarrow 3S + 2H_2O$ $\Delta G^\circ = -91$ kJ
b) $2H_2O_2 \rightarrow O_2 + 2H_2O$ $\Delta G^\circ = -211$ kJ
c) $HCOOH \rightarrow CO_2 + H_2$ $\Delta G^\circ = 119$ kJ
d) $I_2 + Br_2 \rightarrow 2IBr$ $\Delta G^\circ = 7.5$ kJ
e) $NH_4Cl \rightarrow NH_3 + HCl$ $\Delta G^\circ = 92$ kJ

5) Calculate ΔH° and ΔG° for the following reactions at 25°C, interpret the signs of ΔH° and ΔG°.
a) $Al_2O_{3(l)} + 2Fe_{(s)} \rightarrow Fe_2O_{3(s)} + 2Al_{(s)}$ *756.88, 757.01*
b) $COCl_{2(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + 2HCl_{(g)}$ *-116.7, -150.42*

6) Using enthalpies of formation calculate ΔH° for the following reactions at 25°C. Also calculate ΔS° for this reaction from standard entropies at 25 C. Use these values to calculate ΔG° for the reaction at this temperature.
$4HCN + 5O_2 \rightarrow 2H_2O + 4CO_2 + 2N_2$ *-2598.16, -216.78, -2533*

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) CaO(s)
b) CH_3NH_2 (g)
c) CS_2 (*l*)
d) P_4O_{10} (s)

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Thermodynamics – Extra Practice

8) Calculate the standard free energy of the following reactions at 25 C, using standard free energies of formation

a) $C_2H_4\,(g) + O_2\,(g) \rightarrow 2CO_2\,(g) + 2H_2O\,(g)$ *-1314.24*

b) $Na_2CO_3\,(s) + H^+\,(aq) \rightarrow 2Na^+\,(aq) + HCO_3^-\,(aq)$ *-63.19*

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) $HCN + 2H_2 \rightarrow CH_3NH_2$ ΔG° = -92 kJ

b) $N_2 + O_2 \rightarrow 2NO$ ΔG° = 173 kJ

c) $2NO + 3H_2O \rightarrow 2NH_3 + \frac{5}{2}O_2$ ΔG° = 479 kJ

d) $H_2 + Cl_2 \rightarrow 2HCl$ ΔG° = -191 kJ

e) $H_2 + I_2 \rightarrow 2HI$ ΔG° = 2.6 kJ

10) Calculate ΔH° and ΔG° for the following rxns at 25°C, using thermodynamic data; interpret signs of ΔH° and ΔG°.

a) $2PbO + N_2 \rightarrow 2Pb + 2NO$ *620.58, 553.68*

b) $CS_2 + 2H_2O_{(g)} \rightarrow CO_{2(g)} + 2H_2S$; *-38.14, -33.85*

11) Give the expression for the thermodynamic equilibrium constant for each of the following reactions at 298K:

a) $CO(g) + H_2O(g) \rightarrow CO_2\,(g) + H_2\,(g)$ *1.2*

b) $Mg(OH)_2\,(s) \rightarrow Mg^{2+}\,(aq) + 2OH^-\,(aq)$ *9.29×10^{-12}*

c) $2Li(s) + 2H_2O(l) \rightarrow 2Li^+\,(aq) + 2OH^-\,(aq) + H_2\,(g)$ *0.842*

12) What is the standard free energy change ΔG° at 25°C for the following reaction? What is the value of the thermodynamic equilibrium constant K? $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ *-190.6, 2.58×10^{33}*

13) Calculate the standard free energy change and the equilibrium constant K_p for the following reaction at 25°C.
$CO(g) + 3H_2(g) \rightarrow CH_4(g) + H_2O(g)$ *-142.4, 9.27×10^{24}*

14) Obtain the equilibrium constant K_c at 25° C from the free-energy change for the reaction:
$Mg(s) + Cu^{2+} \rightarrow Mg^{2+}\,(aq) + Cu(s)$ *-520.99kJ, 2.08×10^{91}*

15) What is the standard free-energy change ΔG° at 25°C for the following reaction?: $C(graphite) + O_2(g) \rightarrow CO_2(g)$
Calculate the value of the equilibrium constant K. *-394.4, 1.35×10^{69}*

16) Calculate the standard free energy change and the equilibrium constant K_p for the following reaction at 25°C.
$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$ *-29, 1.21×10^{5}*

17) Calculate the equilibrium constant K_c at 25 C from the free-energy change for the reaction:
$Zn(s) + Cu^{2+} \rightarrow Zn^{2+} + Cu(s)$ *-212.19, 1.56×10^{37}*