**Name: Period: Seat#:**

**Worksheet #4\***

 **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*.* 2CH3OH(l) + 3O2 (g) → 2CO2 (g) + 4H2O(l) *-1452.1, -164.8, -1403.0*

1. The free energy of formation of one mole of compound refers to a particular chemical equation. For each of the following, write that equation.
2. NaCl (s)
3. HCN (*l*)
4. SO2 (g)
5. PH3 (g)
6. Calculate the standard free energy of the following reactions at 25°C, using standard free energies of formation.

|  |
| --- |
| 1. CH4 (g) + 2O2 (g) → CO2 (g) + 2H2O(g) *-800.76*
 |
| 1. CaCO3 (s) + 2H+ (aq) → Ca2+ (aq) + H2O(*l*) + CO2 (g) *-56.1*
 |

1. On the basis of ΔG° for each of the following rxns, 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.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. SO2 + 2H2S → 3S + 2H2O
 | ΔG° = -91 kJ | 1. I2 + Br2 → 2IBr
 | ΔG° = 7.5 kJ |
| 1. 2H2O2 → O2 + 2H2O
 | ΔG° = -211 kJ | 1. NH4Cl → NH3 + HCl
 | ΔG° = 92 kJ |
| 1. HCOOH → CO2 + H2
 | ΔG° = 119 kJ |  |  |

1. Calculate ΔH° and ΔG° for the following reactions at 25°C, interpret the signs of ΔH° and ΔG°.

|  |  |
| --- | --- |
| 1. Al2O3 (l) + 2Fe(s) → Fe2O3(s) + 2Al(s) *756.88, 757.01*
 | 1. COCl2(g) + H2O(g) → CO2(g) + 2HCl(g)  *-116.7, -150.42*
 |

1. 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 + 5O2 → 2H2O + 4CO2 + 2N2 *-2598.16, -216.78, -2533*
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.

|  |
| --- |
| 1. CaO(s)
 |
| 1. CH3NH2 (g)
 |
| 1. CS2 (*l*)
 |
| 1. P4O10 (s)
 |

1. Calculate the standard free energy of the following reactions at 25 C, using standard free energies of formation.

|  |
| --- |
| 1. C2H4 (g) + O2 (g) → 2CO2 (g) + 2H2O (g) *-1314.24*
 |
| 1. Na2CO3 (s) + H+ (aq) → 2Na+ (aq)+ HCO3− (aq) *-63.19*
 |

1. 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)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. HCN + 2H2 → CH3NH2
 | ΔG° = -92 kJ |  | 1. H2 + Cl2 → 2HCl
 | ΔG° = -191 kJ |
| 1. N2 + O2 → 2NO
 | ΔG° = 173 kJ |  | 1. H2 + I2 → 2HI
 | ΔG° = 2.6 kJ |
| 1. 2NO + 3H2O → 2NH3 + $\frac{5}{2}$O2
 | ΔG° = 479 kJ |  |  |  |

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

|  |
| --- |
| 1. 2PbO + N2 → 2Pb + 2NO *620.58, 553.68*
 |
| 1. CS2 + 2H2O(g) → CO2(g) + 2H2S; *-38.14, -33.85*
 |

1. Give the expression for the thermodynamic equilibrium constant for each of the following reactions at 298K:

|  |
| --- |
| 1. CO(g) + H2O(g) → CO2 (g) + H2 (g) *1.2 x 105*
 |
| 1. Mg(OH)2 (s) → Mg2+ (aq) + 2OH− (aq) *9.29 x 10-12*
 |
| 1. 2Li(s) + 2H2O(*l*) → 2Li+ (aq) + 2OH− (aq) + H2 (g) *0.842*
 |

1. 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? H2(g) + Cl2(g) → 2HCl(g) *-190.6, 2.58 x 1033*
2. Calculate the standard free energy change and the equilibrium constant Kp for the following reaction at 25°C.
CO(g) + 3H2(g) → CH4(g) + H2O(g)  *-142.4, 9.27 x 1024*
3. Obtain the equilibrium constant Kc at 25° C from the free-energy change for the reaction:
Mg(s) + Cu2+ → Mg2+ (aq) + Cu(s)*-520.99kJ, 2.08 x 1091*
4. What is the standard free-energy change ΔG° at 25°C for the following reaction?: C(graphite) + O2(g) → CO2(g) Calculate the value of the equilibrium constant K. *-394.4, 1.35 x 1069*
5. Calculate the standard free energy change and the equilibrium constant Kp for the following reaction at 25°C.
CO(g) + 2H2(g) → CH3OH(g) *-29, 1.21 x 105*
6. Calculate the equilibrium constant Kc at 25 C from the free-energy change for the reaction:
Zn(s) + Cu2+ → Zn2+ + Cu(s) *-212.19, 1.56 x 1037*

**EVEN MORE PRACTICE! - Hard work now during the chapter will set you up for success and save you time
 long term! Make smart, mature choices!**

1. Read, take notes, try some problems from your Tro online Textbook. Remember that the textbook often covers more material than we need for this class. If it isn’t something I talked about in my lectures/handouts/ worksheets, then you can skip it! I won’t officially assign reading or problems from the textbook because it isn’t a very efficient way to teach this class, but some students might need to read the textbook sections or do extra practice in order for things to “click” differently for them. That is ok! Not everyone is going to need the same amount or type of studying. A lot of this class is figuring out what you personally need to do in order to feel successful. You will have access to the textbook all year, don’t forget about it!



* [https://www.mlm.pearson.com/northamerica/
masteringchemistry/](https://www.mlm.pearson.com/northamerica/masteringchemistry/%20)
	+ - Chapter 18: Free Energy and
		Thermodynamics
1. Don’t forget that there is extra practice on the class website too! [www.mychemistryclass.net](http://www.mychemistryclass.net)
AP Chem Tab 🡪 Study Materials Link 🡪 Scroll to the chapter we are on 🡪 Extra Study Materials Link.
	* + I don’t always have answer keys for the extra materials. If there is one, it will be in the folder!
2. ScienceGeek.net has some good online practice tests. I haven’t checked all of them, but the ones I have checked are pretty good! [https://www.sciencegeek.net/APchemistry/APtaters/
directory.shtml](https://www.sciencegeek.net/APchemistry/APtaters/directory.shtml)
3. Don’t forget that there is extra practice on GoFormative too! [www.goformative.com](http://www.goformative.com)
	* + Another teacher made some assignments on GoFormative the year the school was Remote due to Covid. I have not proofread all the remote assignments, but I have published them so they are available for you to try if you would like!
4. Don’t forget that there is extra practice on AP Classroom too! <https://myap.collegeboard.org>
	* + AP Classroom is a bit clunky, doesn’t allow me to easily post questions in the order we go, sometimes crashes, still has old material we no longer cover, etc. BUT it is a source of questions that we know came from College Board!
		+ You can use the “tags” I made to pull up practice that is just on the chapter you are interested in studying.
5. Don’t forget that our school has free peer tutoring available through the Academic Leadership class! The links for peer tutoring are on the top of my Class Calendar.
6. Don’t forget that you can sign up for my Access periods! You must sign up by Tuesday 8am of the week you want to attend. The links are on the front page of my class website and at the top of my Class Calendar.