**Thermodynamics homework (fuel cells, black powder, thermite calculations)**

Instructions: Do your calculations on this worksheet, and then enter your answers in the Canvas multiple-choice “quiz” which has the same title.

Hess’ Law: ∆H°reaction = ∑∆H°f (products)  - ∑∆H°f (reactants)

Entropy change: ∆S°reaction = ∑∆S° (products)  - ∑∆S° (reactants)

Gibb’s Free Energy: ∆G°reaction = ∆H°reaction - T∆S°reaction (T=298°K under standard conditions)

1. Hydrogen Fuel Cells

The following reaction takes place in a hydrogen “fuel cell”:

 hydrogen oxygen water electrical

 gas (fuel) gas (harmless) energy

 2H2 + O2 → 2H2O + energy

1. What is the enthalpy of reaction (∆H°reaction) for this process? In other words, if we burn 2 moles of hydrogen in the presence of 1 mole of pure oxygen to create water and energy (that’s what a hydrogen fuel cell does), how much heat in kilojoules (KJ) is consumed (+) or produced (-)?
2. What are some of the drawbacks to a hydrogen fuel cell? In other words, why isn’t this powering all our cars? Research pros & cons of “hydrogen fuel cells” and “the hydrogen economy”.

Choose the best 3 answers in Canvas.

1. Black Powder

The chemical equation for the “black powder” reaction can be simplified as follows:

 carbon potassium sulfur potassium potassium carbon nitrogen (pulverized charcoal) nitrate carbonate sulfate dioxide gas

 8C + 10KNO3 + 3S → 2K2CO3 + 3K2SO4 + 6CO2↑ + 5N2↑

∆H°f : 0 KJ/mol -495 0 -1,151 -1430 -393 0

S° : .006 KJ/mol °K .13 .03 .17 .17 .21 .19

1. Using Hess’ Law, calculate the Gibb’s Free Energy ∆G° for this process.

In Canvas, this is split into 3 parts: the enthalpy of reaction, then the entropy change, and finally the Gibbs free energy.

1. Based on the answer, is it a “spontaneous” reaction?

Note: Question 3 isn’t included in the Canvas “quiz”, but is here for practice.

1. Thermite Reaction

The chemical equation for the thermite reaction is as follows:

 red iron aluminum aluminum iron

 oxide oxide

Fe2O3 + 2Al → Al2O3 + 2Fe

∆H°f → -824 KJ/mol 0 -1,676 0

S° → 0.087 KJ/mol °K 0.028 0.051 0.027

1. Using Hess’ Law, calculate the Gibb’s Free Energy ∆G° for this process.
2. Based on the answer, is it a “spontaneous” reaction?