R = 8.31 joule/mol K.

**Assume that all reactions in this exam take place at 298.15K**

**Thermodynamic Quantities. (At 298.15 K )**

|  |  |  |  |
| --- | --- | --- | --- |
| Substance |  **ΔHof kJ/mol)** |  **ΔGof (kJ/mol)** |  **So (J/mol K)** |
| C6H6 (*l*) |  49.0 |  124.5 |  172.8 |
| C6H6(g) |  82.9 |  129.7 |  269.2 |
| C2H4(g) |  52.30 |  68.11 |  219.4 |
| C2H5OH(*l*) |  -277.7 |  -174.76 |  160.7 |
| H2(g) |  0 |  0 |  130.58 |
| Cl(g) |  121.7 |  105.7 |  165.2  |
| CO2(g) | –393.5 | – 394.4 | 213.6 |
| C2H6(g) | –84.68 | –32.89 | 229.5 |
| HCl(g) |  | – 95.27 |  |
| H2O(*l*) |  -285.85 |  -236.81 |  69.96 |

Heat of combustion of ethanol C2H5OH(*l)*  + 3 O2(g) ➞ 2 CO2(g)  + 3 H2O(g)

ΔH° = –1234.76 kJ/mol ΔG = ΔG° + RT Ln Q

Second Lecture test in chemistry 2. Spring 2011.

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Part I: Multiple Choice and fill -in questions. These must be answered in the spaces provided with the questions. (1 and 3/4 pts each)

\_\_\_\_\_\_\_1. A certain reaction is spontaneous only at temperatures below 380 K. At 298 K, for this reaction, ΔG° , ΔH°, and ΔS° , respectively are

 A) all + B) all − C) − , +, + D) +, − ,− E) −, −, +

\_\_\_\_\_\_\_2. Find the value of ΔG° in kJ/ mol for the conversion of liquid benzene to gaseous benzene at 298 K. ( C6H6(ℓ) → C6H6(g) )

 A) 124.5 B) 129.7 C) 5.2 D) −5.2 E) −129.5

\_\_\_\_\_\_3. For the reaction H2(g) + Cl2(g) → 2 HCl(g), Δ H° is − 184.6 kJ

 What is the standard heat of formation of HCl(g)?

 A) + 92.3 kJ/mol B) −92.3 kJ/mol C) + 184.6 kJ/mol D) −369.2 kJ

 E) + 369.2 kJ

\_\_\_\_\_\_\_4. What is the value of ΔG° for reaction at 298 K if the equilibrium constant for that reaction at 298 K is 1.00? A) 1.00 B) 2.48 kJ C) −2.48 kJ

 D) 0 E) −1

\_\_\_\_\_\_5. Which of the following would have the greatest standard entropy, S°?

 A) H2 gas at 300 K, and 1.00 atm B) He gas at 200 K and 2.00 atm

 C) SO2 gas at 300 K and 0.80 atm D) NO2 gas at 200 K and 2.00 atm

 E) Br2 liquid at 300 K and 1.00 atm

\_\_\_\_\_\_6. Which has a ΔGof (standard free energy of formation) of ZERO ?

 A) O(g) B) NH3(g) C) S(g) D) N2(g)

For the following questions, 7 to 12, the answers are +, –, or 0. (assume that T=298K)

\_\_\_\_\_\_\_7. ΔGof , the free energy of formation, of N2(g)

\_\_\_\_\_\_\_8. ΔH° f, the standard enthalpy of formation, of CO2(s)

\_\_\_\_\_\_\_9 ΔGof of NH3(g), given that the equilibrium constant for the reaction

 N2(g) + 3 H2(g) ➞ 2 NH3(g) is 6.7 x 105

\_\_\_\_\_\_\_10. S° , the standard molar entropy of NaCl(s) at 298 K.

\_\_\_\_\_\_\_11. ΔS° for the reaction 2 Na(s) + Cl2(g) → 2 NaCl(s)

\_\_\_\_\_\_\_12. ΔG° for the condensation of benzene, C6H6(g) → C6H6(ℓ)

\_\_\_\_\_\_\_13. For which of the following processes are ΔG° , ΔH°, and ΔS° all positive in

 sign at 25°C ? A) melting of ice B) condensation of water vapor

 C) freezing of water D) decomposition of liquid water to hydrogen and oxygen gas.

\_\_\_\_\_\_14. Reactions for which the signs of ΔH and ΔS are **both** negative will be spontaneous

A) at high temperatures B) at low temperatures C) at all temperatures D) at no temperatures

\_\_\_\_\_\_\_\_\_\_\_\_\_15. ΔH° for the melting of ice at 0°C, (the heat of fusion) is 6.0 kJ/mole.

 What is ΔS° for the melting of ice at that temperature?

\_\_\_\_16. For a certain reaction, ΔG̊ at 298 K is negative. This implies that

 A) The equilibrium constant is > 1 B) The equilibrium constant is < 1

 C) The reaction is spontaneous at all temperatures

 D) ΔH̊ is negative at 298 K

 I. For the combustion of liquid ethanol, C2H5OH(*l*) + 3O2(g) → 2 CO2(g) + 3 H2O(*l*)

(12)

A. Find ΔG°, ΔH°, and ΔS° at 298.15 K. (note that the combustion given on the accompanying chart forms **gaseous** water, while this question refers to formation of liquid water)

 B. Find the standard molar entropy, S°, of O2(g) .

C. By comparing your value for ΔG° from part A with the value given on the chart for the combustion of ethanol with the formation of **gaseous** water, find the free energy of vaporization of water in kJ/mol. (ΔG° for H2O(ℓ) → H2O(*g*) )

II. A. Find the equilibrium constant at 298 K for the reaction H2(g)+ Cl2(g) → 2 HCl(g)

(8) B. Find the value of ΔG for this reaction at 298 K when the partial pressures of the three gases are as follows: H2 = 3.00 atm, Cl2 = 3.00 atm, HCl = 4.00 x 10−5 atm.

III. For the reaction H2(g) + Cl2(g) → 2 HCl(g), ΔH̊ = –184.6 kJ.

Use the information above and the information on the accompanying chart to find the value of ΔS̊ for the reaction given. (at 298 K) ( 3 pts)