Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_

# AP Chemistry: *19HW*

***Directions: Complete the following problems.***

What is the sign of the change in entropy for each process?

1A. melting 1B. mixing two components of a mixture

subliming separating a mixture’s components

freezing boiling

2A. Butane (C4H10) has a boiling point of –1oC and a heat of vaporization of 22.44 kJ/mol. Determine the entropy of vaporization for butane.

2B. Ethane has an enthalpy of vaporization of 14.7 kJ/mol and an entropy of vaporization of 79.9 J/K-mol. Determine ethane’s normal boiling point, in oC.

Which species has the greater entropy?

3A. 1 mol N2 or 1 mol N2 3B. 1 mol O2 or 1 mol O2

at STP at 200oC, 0.25 atm at STP at 50K, 3.0 atm

1 mol H2O(l) or 1 mol H2O(g) 1 mol CH4(g) or 1 mol H2O(l)

at 100oC at 100oC at 0oC at 75oC

Predict the sign of the standard entropy change for each reaction. Then use tabulated values to calculate So.

4A. 2 NO2(g) 🡪 2 NO(g) + O2(g)

4B. 2 H2(g) + O2(g) 🡪 2 H2O(l)

ANSWERS: 2A. 82.5 J/mol-K 2B. –89oC 4A. +146 J/K 4B. –327 J/K

For the reactions below: i. Predict the sign of Ho.

ii. Calculate Ho using tabulated values.

iii. Predict the sign of So.

iv. Calculate So using tabulated values.

v. Calculate Go using tabulated values.

vi. State whether or not the reaction is spontaneous, under standard conditions.

5A. C3H8(g) + 5 O2(g) 🡪 3 CO2(g) + 4 H2O(g)

5B. 6 CO2(g) + 6 H2O(l) 🡪 C6H12O6(s) + 6 O2(g)

ANSWERS: 5Aii. –2045 kJ 5Av. –2074 kJ 5Biv. –262 J/K

5Aiv. +103 J/K 5Bii. +2802 kJ 5Bv. +2875 kJ

At what temperature range, if any, will each process be spontaneous?

6A. H = –21 kJ, S = –70. J/K 6C. H = +21 kJ, S = –70. J/K

6B. H = –21 kJ, S = +70. J/K 6D. H = +21 kJ, S = +70. J/K

7A. For the reaction 2 NO(g) + O2(g) 🡨🡪 N2O4(g) Ho = –170.6 kJ and So = –322.4 J/K. Use tabulated values to find Go. Then find the Celsius temperature at which G = 0. Finally, state the temperature range over which the reaction is spontaneous and the temperature range over which it is NOT spontaneous.

7B. At 100.oC and 1.00 atm, Hvap = 40.6 kJ/mol for water. Estimate G at 75oC and at 115oC.

ANSWERS: 6A. spont. at T < 300 K 6C. NOT spont. at any T 7A. –75.4 kJ; 256oC; T < 256oC; T > 256oC 6B. spont. at all T 6D. spont. at T > 300 K 7B. +2.72 kJ/mol; –1.63 kJ/mol

Use tabulated values to calculate G at 298 K for the given reaction under the specific set of conditions.

8A. PCl3(g) + Cl2(g) 🡨🡪 PCl5(g) 8B. 2 SO3(g) 🡨🡪 O2(g) + 2 SO2(g)

P(PCl3) = 0.010 atm P(SO3) = 0.840 atm

P(Cl2) = 0.017 atm P(O2) = 0.011 atm

P(PCl5) = 0.925 atm P(SO2) = 0.022 atm

9A. For the reaction 2 NO(g) + O2(g) 🡨🡪 N2O4(g) Ho = –170.6 kJ and So = –322.4 J/K. Determine the value of K at 25oC and estimate the value of K at 200.oC.

9B. Consider the reaction H2(g) + Br2(g) 🡪 2 HBr(g).

i. Find K at 25oC.

ii. Now, assume that the three gases above are placed in a container, with each gas having a partial

pressure of 0.5 atm. In which direction will the system shift to achieve equilibrium? Also, state

whether each gas’s pressure will increase or decrease.

ANSWERS: 8A. –17 kJ 9A. 1.6 x 1013 (or 1.1 x 1013); 1500 9Bi. 1.3 x 1019

8B. –29 kJ 9Bii. shift 🡪

For the reaction HNO2(aq) 🡨🡪 H+(aq) + NO2–(aq), Ka = 4.6 x 10–4 at 25oC. For each set of conditions, decide in which direction, if any, the reaction will shift to reach equilibrium. Also, decide which sign G has under those conditions.

10A. [HNO2] = [H+] = [NO2–] = 0.25 M 10C. [HNO2] = 0.35 M, [H+] = [NO2–] = 0.0041 M

10B. [HNO2] = [H+] = [NO2–] = 2.5 x 10–6 M 10D. [HNO2] = [NO2–] = 0.18 M, [H+] = 4.6 x 10–4 M

11A. Given the following: 2 H2(g) + C(s) 🡪 CH4(g) Go = –51 kJ

2 H2(g) + O2(g) 🡪 2 H2O(l) Go = –474 kJ

C(s) + O2(g) 🡪 CO2(g) Go = –394 kJ

Determine Go for CH4(g) + 2 O2(g) 🡪 CO2(g) + 2 H2O(l).

11B. Given the following: C(s) + O2(g) 🡪 CO2(g) Go = –394 kJ

H2(g) + ½ O2(g) 🡪 H2O(l) Go = –237 kJ

2 C6H6(l) + 15 O2(g) 🡪 12 CO2(g) + 6 H2O(l) Go = –6399 kJ

Determine Go for 6 C(s) + 3 H2(g) 🡪 C6H6(l).

ANSWERS: 10A. Shift 🡨; G is + 10C. Shift 🡪; G is – 11A. –817 kJ

10B. Shift 🡪; G is – 10D. No shift; G = 0 11B. +125 kJ

# AP Chemistry: *Thermodynamic Data*

**Substance and State Hfo (kJ/mol) Gfo (kJ/mol) So (J/mol-K)**

Br2(g) 31 3.14 245

Br2(l) 0 0 152

CO2(g) –393.5 –394 214

C3H8(g) –104 –24 270.

C6H12O6(s) –1275 –911 212

Cl2(g) 0 0 223

CH3CH2OH(g) –235.1 –168 282.7

CH3CH2OH(l) –277.7 –175 160.7

HBr(g) –36 –53 199

HCl(g) –92 –95 187

H2(g) 0 0 131

H2O(l) –286 –237 70.

H2O(g) –242 –229 189

H2S(g) –21 –34 206

NH3(g) –46 –17 193

NO(g) 90.3 86.7 210.7

NO2(g) 33.2 51.8 240.

N2O4(g) 10. 98 304

O2(g) 0 0 205

O3(g) 143 163 239

P4(s) 0 0 177

PCl3(g) –270. –286.3 312

PCl3(l) –272 –320 217

PCl5(g) –278 –324.6 353

S(s) 0 0 32

SO2(g) –297 –300. 248

SO3(g) –396 –371 257