Brooklyn College
Chemistry Department
Summer 2010, Lecture test 3.

Name_____

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 | **$\Delta H^o_f$ kJ/mol)** | **$\Delta G^o_f$ (kJ/mol)** | **$S^o$ (J/mol K)** |
|---|---|---|---|
| $C_6H_{6\,(l)}$ | 49.0 | 124.5 | 172.8 |
| $C_6H_{6(g)}$ | 82.9 | 129.7 | 269.2 |
| $C_2H_{4(g)}$ | 52.30 | 68.11 | 219.4 |
| $C_2H_5OH_{(l)}$ | -277.7 | -174.76 | 160.7 |
| $H_2(g)$ | 0 | 0 | 130.58 |
| $NH_{3(g)}$ | –46.19 | –16.66 | |
| $CO_{2(g)}$ | –393.5 | – 394.4 | 213.6 |
| $C_2H_{6(g)}$ | –84.68 | –32.89 | 229.5 |
| $HCl_{(g)}$ | | – 95.27 | |
| $H_2O_{(l)}$ | -285.85 | -236.81 | 69.96 |

$\Delta G = \Delta G° + RT \ln Q$

<u>Ksp values at 298 K.</u>

$BaCrO_4$ $2.1 \times 10^{-10}$

$CaF_2$ $3.9 \times 10^{-11}$

AgCl $1.3 \times 10^{-11}$

$Ag_2CrO_4$ $1.2 \times 10^{-12}$

Name_____

Short items must be answered on these pages in the spaces provided. (3 pts each)

_____1. The molar solubility of AgI is found to be $9.1 \times 10^{-9}$ M. What is the Ksp of silver iodide?

_____2) Which of these salts has the greatest molar solubility?
A) $CaF_2$ B) $BaCrO_4$ C) AgCl D) $Ag_2CrO_4$

_____3. Solid $CaF_2$ is added to water until the solution becomes just saturated. What is the $[F^-]$ in this saturated solution?
A) $3.9 \times 10^{-11}$ M B) $2.13 \times 10^{-4}$ M C) $4.26 \times 10^{-4}$ M D) $2.0 \times 10^{-11}$ M

_____4. The solubility of $Ag_2SO_4$ in an aqueous solution would be **decreased** by the addition of A) nitric acid B) sulfuric acid C) sodium nitrate D) 12 molar ammonia solution

_____5. Find the molar solubility of $CaF_2$ in a solution that is 0.200 molar in NaF.

_____6. Which is the correct formula for a precipitate formed in group I qualitative analysis? A) $BaSO_4$ B) $Pb(NO_3)_2$ C) $Hg_2Cl_2$ D) CuS

7 to 9 - which has the highest standard molar entropy, S°?

_____7. A) $SO_2(g)$ B) $SO_3(g)$ C) $H_2O(g)$ (all at 120°C and 1 atm)

_____8. A) $N_2(g)$ at 1.0 atm and 298 K B) $N_2(g)$ at 0.50 atm and 350 K C) $N_2(g)$ at 0.50 atm and 298 K

_____9. A) $Br_2(\ell)$ B) I(s) C) $Cl_2(g)$

In each of the following questions,(10 to 15) indicate by writing + , − , or 0 whether each of the quantities described is positive, negative or 0.

_____10. $\Delta G°$ for the melting of ice at 25°C

_____11. $\Delta H°$ for the melting of ice at 25°C

_____12. $\Delta S°$ for the formation of ammonia gas from nitrogen and hydrogen gas

_____13. $\Delta G°$ for the reaction $C_2H_6\ (g) \rightarrow 2\ C\ (s) + 3\ H_2(g)$

_____14. $\Delta H°$ for a reaction that is spontaneous at low temperatures, but NOT at high temperatures.

_____15. $S°$ of Na(s) at 298 K

16. Consider the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$ at 298 K.

_____A. Find $\Delta H°$ for the reaction (actual value, not just +,- or 0 !)

_____B. Find $\Delta S°$ for the reaction.

_____C. $\Delta G°$ for this reaction would be **negative** at
A) low temperatures only B) high temperatures only
C) all temperatures D) no temperatures.

Problems: Must be answered in blue exam booklets.

I. How many **grams** of $CaF_2$ are required to exactly saturate 100.0 mL of aqeous solution? (Show work step by step!) ( 8 pts)

II. Would a precipitate form when 1.00 mL of 0.0100 molar $AgNO_3$ is added to 99.0 mL of $2.0 \times 10^{-3}$ molar $K_2CrO_4$ ? Show calculations that support your answer. No credit for a simple "Yes" or "No." ( 8 pts)

III. For the reaction $C_2H_5OH(\ell) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(\ell)$ at 298

A. Find $\Delta H°$, $\Delta G°$, and $\Delta S°$ (9 pts)

B. Find $S°$, the standard molar entropy, of $O_2$ (g) (3 pts)

C. For the same reaction, forming **gaseous** water, $\Delta G°$ is $-1299.75$ kJ. Find the value of $\Delta G°$ at 298 K for the vaporization of water, $H_2O\ (\ell) \rightarrow H_2O(g)$ (3 pts)

IV. Find the equilibrium constant for the reaction $C_2H_4(g) + H_2\ (g) \rightarrow C_2H_6(g)$ at 298 K. ( 4 pts)

B. Predict how this equilibrium constant will change if the temperature is increased. Explain your answer briefly. ( 3pts)

V. Use the information on the chart from page 1 to determine whether $C_6H_6$ is a liquid or a gas at 298 K and 1.00 atmosphere. Justify your answer

(3)

VI. For the reaction at 298 K $H_2(g) + Cl_2(g) \rightarrow 2\ HCl(g)$

A. Determine the value of $\Delta G°$ (3)

B. Determine the value of $\Delta G$ when the pressures of the three gases at 298 K are as follows:
$H_2 = 2.00 \times 10^{-3}$ atm, $Cl_2 = 3.00 \times 10^{-3}$ atm, and $HCl = 5.00$ atm. (6)

Extra Credit: Calculate the temperature above which the Keq for the formation reaction of ammonia gas becomes **less than 1.** (You must assume that $\Delta H°$ and $\Delta S°$ remain constant despite changes in temperature.) (3 pts)

Extra Credit II ( 2 pts) What is the modern name for the substance that was originally called "dephlogisticated air"? Who discovered this substance?