

INTRODUCTORY CHEMISTRY, CHEM112
TEST #2, FALL 2004

Name _____

Multiple Choice: Circle the best answer to each question. There is only one correct answer for each question.

$$R = 8.314 \text{ J/mol}\cdot\text{K} = 0.0821 \text{ L}\cdot\text{atm/mol}\cdot\text{K} \quad F = 96,485 \text{ C/mol } e^-$$

- Determine the oxidation number for bromine in HBrO_4 .
a) +6 b) +7 c) +8 d) -6 e) -7 f) -8
- Determine the oxidation state of the carbon atom in bold print: $\text{CH}_3\text{CH}_2\text{F}$
a) 0 b) +1 c) +2 c) +3 e) -1 f) -2
- Which of the following is true about the reaction below?
$$2\text{VO}^{2+}(\text{aq}) + \text{Br}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{VO}_2^+(\text{aq}) + 2\text{Br}^-(\text{aq}) + 4\text{H}^+$$

a) Br_2 is acting as a reducing agent
b) VO_2^+ is acting as a weak reducing agent
c) VO^{2+} is oxidized
d) H_2O is reduced
e) H^+ is acting as a weak reducing agent
- What will be the coefficients in front of Ce^{4+} and Cl^- when the following reaction is balanced?
$$\text{Ce}^{4+}(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{aq}) + \text{Ce}^{3+}(\text{aq})$$

a) 1,1 b) 1,2 c) 2,1 d) 2,2 e) 3,1 f) none of these
- Use the following half reactions and accompanying standard reduction potentials to determine the best reducing agent.

	E°_{Red}
$\text{Ga}^{3+} + 3e^- \rightarrow \text{Ga}$	-0.560 V
$\text{Be}^{2+} + 2e^- \rightarrow \text{Be}$	-1.70 V
$\text{Pd}^{2+} + 2e^- \rightarrow \text{Pd}$	+0.987 V

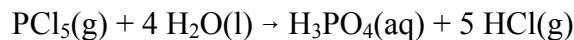
a) Ga^{3+} b) Ga c) Be^{2+} d) Be e) Pd^{2+}
f) Pd
- Carbonated beverages can be made by bubbling carbon dioxide gas through the aqueous beverage and allowing the carbon dioxide to dissolve. Predict the sign of ΔH° and ΔS° for the following reaction without using tables.
$$\text{CO}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{aq})$$

a) $\Delta H^\circ = +$, $\Delta S^\circ = +$ b) $\Delta H^\circ = -$, $\Delta S^\circ = +$ c) $\Delta H^\circ = -$, $\Delta S^\circ = -$
d) $\Delta H^\circ = +$, $\Delta S^\circ = -$

7. For each of the following variables what is the appropriate sign that is favorable for a spontaneous reaction?
- a) $\Delta H^\circ = +$, $\Delta S^\circ = +$, $\Delta G^\circ = +$, $E^\circ = +$ b) $\Delta H^\circ = -$, $\Delta S^\circ = +$, $\Delta G^\circ = +$, $E^\circ = +$
 c) $\Delta H^\circ = +$, $\Delta S^\circ = +$, $\Delta G^\circ = -$, $E^\circ = +$ d) $\Delta H^\circ = +$, $\Delta S^\circ = +$, $\Delta G^\circ = +$, $E^\circ = -$
 e) $\Delta H^\circ = -$, $\Delta S^\circ = +$, $\Delta G^\circ = -$, $E^\circ = -$ f) $\Delta H^\circ = -$, $\Delta S^\circ = +$, $\Delta G^\circ = -$, $E^\circ = +$
8. Which of the following reactions will have a positive ΔS ?
- a) $\text{CO(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_3\text{OH(l)}$
 b) $\text{NaCl(s)} \rightarrow \text{Na}^+\text{(aq)} + \text{Cl}^-\text{(aq)}$
 c) $\text{CH}_4\text{(g)} + 2\text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)}$
 d) $3\text{H}_2\text{(g)} + \text{N}_2\text{(g)} \rightarrow 2\text{NH}_3\text{(g)}$
 e) none of these
9. Under which one of the following conditions will the following reaction be spontaneous?
 $2\text{CO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO}_2\text{(g)}$ $\Delta H^\circ = -565.97 \text{ kJ/mol}_{\text{rxn}}$, $\Delta S^\circ = -173.0 \text{ J/mol}_{\text{rxn}}\cdot\text{K}$
- a) spontaneous at all temperatures b) spontaneous at high temperatures
 c) spontaneous at low temperatures d) not spontaneous at any temperature
10. If a forward reaction is spontaneous what can be said about the reverse reaction under the same conditions?
- a) the reverse reaction is nonspontaneous
 b) the reverse reaction is spontaneous also
 c) the reverse reaction is at equilibrium
 d) none of these are true

Problems: Show your work in a neat orderly fashion. Include all units and maintain significant figures.

1. It is possible to make hydrogen chloride by reacting phosphorus pentachloride with water and boiling the HCl out of the solution. Use tables of atom combination data to calculate ΔH° and ΔS° for this reaction. Does ΔH° favor formation of products or reactants? Does ΔS° favor formation of products or reactants?



$\Delta H^\circ =$ _____ $\Delta S^\circ =$ _____ ΔH° favors _____ ΔS° favors _____

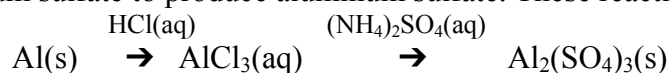
2. Use the following table to find the standard reduction potential, E°_{Red} , for the half reactions listed below. Given: $\text{Zn}^{2+} + 2e^- \rightarrow \text{Zn}$ $E^\circ_{\text{Red}} = -0.76\text{V}$.

Measured voltages for galvanic cells using standard conditions

Cathode	Anode	$E^\circ(\text{V})$
Cu/Cu ²⁺	Zn/Zn ²⁺	1.10
Cu/Cu ²⁺	SHE	0.34
Br ₂ /Br ⁻	Zn/Zn ²⁺	1.85
Zn/Zn ²⁺	K/K ⁺	2.16
Cl ₂ /Cl ⁻	Ag/Ag ⁺	0.56
Ag/Ag ⁺	K/K ⁺	3.72



3. When aluminum metal is dissolved by reacting with hydrochloric acid to produce aqueous aluminum chloride a gas is observed to be given off. The aluminum chloride can then be reacted with ammonium sulfate to produce aluminum sulfate. These reactions are summarized below:



Write the balanced molecular and net ionic equations for these two reactions. Indicate whether each is an oxidation-reduction reaction.

4. An iron/tin galvanic cell is constructed. An iron strip is placed into a 1.0M solution of $\text{Fe}(\text{NO}_3)_3$ and this electrode is connected by a salt bridge to an electrode consisting of a strip of tin in a 1.0 M $\text{Sn}(\text{NO}_3)_2$ solution. The tin strip is observed to dissolve.

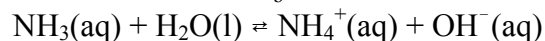
a) Identify the anode and cathode.

b) Write the reduction half reaction

c) Write the oxidation half reaction

d) What is the overall spontaneous chemical reaction?

5. Use tables of atom combination data to calculate ΔG° for the following reaction at 298 K. Use the ΔG° to calculate the value of K_b for ammonia at 298 K.



$\Delta G^\circ =$ _____ $K_b =$ _____

Does this reaction favor the reactants or products when run under standard conditions?

Discussion: Use complete sentences and correct grammar.

1. Distinguish between the following terms:

a) K_c and K_p

b) ΔG° and ΔG

c) ΔH° and ΔS°

2. The standard free energy change for the evaporation of water at 298 K is found to be +8.56 kJ/mol_{rxn}.



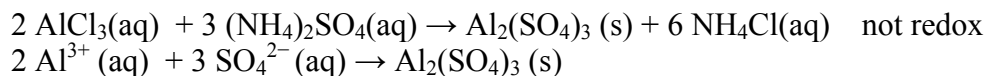
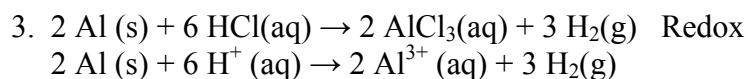
The ΔG° indicates that the evaporation of water at 298 K is *nonspontaneous* under *standard conditions*. If a beaker of water is set out on a table in the room why will it spontaneously evaporate?

Test # 2 Fall 2004 Answers.

- | | |
|------|-------|
| 1. b | 6. c |
| 2. e | 7. f |
| 3. c | 8. b |
| 4. d | 9. c |
| 5. d | 10. a |

1. $\Delta H^\circ = -220.8 \text{ kJ/mol}_{\text{rxn}}$ $\Delta S^\circ = +68 \text{ J/mol}_{\text{rxn}} \text{ K}$
 ΔH° favors products ΔS° favors products

2. a) $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ $E^\circ_{\text{Red}} = +1.36 \text{ V}$
 b) $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ $E^\circ_{\text{Red}} = +0.80 \text{ V}$



4. a) anode Sn cathode Fe
 b) $\text{Fe}^{3+} + 3\text{e}^- \rightarrow \text{Fe}$
 c) $\text{Sn} \rightarrow \text{Sn}^{2+} + 2\text{e}^-$
 c) $2 \text{Fe}^{3+} + 3 \text{Sn} \rightarrow 2 \text{Fe} + \text{Sn}^{2+}$

5. $\Delta G^\circ = +27.07 \text{ kJ/mol}_{\text{rxn}}$ $K_b = 1.8 \times 10^{-5}$ This reaction favor the reactants

6. a) K_c is the equilibrium constant based on molar concentrations.
 K_p is the equilibrium constant based on partial pressure of gases.

b) ΔG° is the change in free energy for a reaction measured under standard conditions.
 ΔG is the change in free energy for a reaction measured under conditions other than standard conditions.

c) ΔH° is the change in enthalpy for a reaction measured under standard conditions.
 ΔS° is the change in entropy for a reaction measured under standard conditions.

7. ΔG° measures the tendency for the reaction to occur under standard conditions. This would be for evaporation of water in a container (or room) where there was already a 1 atm partial pressure of water in the gaseous state. One atm of pressure is equivalent to the full pressure of the atmosphere presently pushing down on you but in this case it would be due entirely to water. Even when the atmosphere is completely saturated with water vapor the partial pressure due to water is much less than 1 atm. Water spontaneously evaporates in a room because the ΔG is negative for the conditions in the room even if the ΔG° at standard conditions is not.