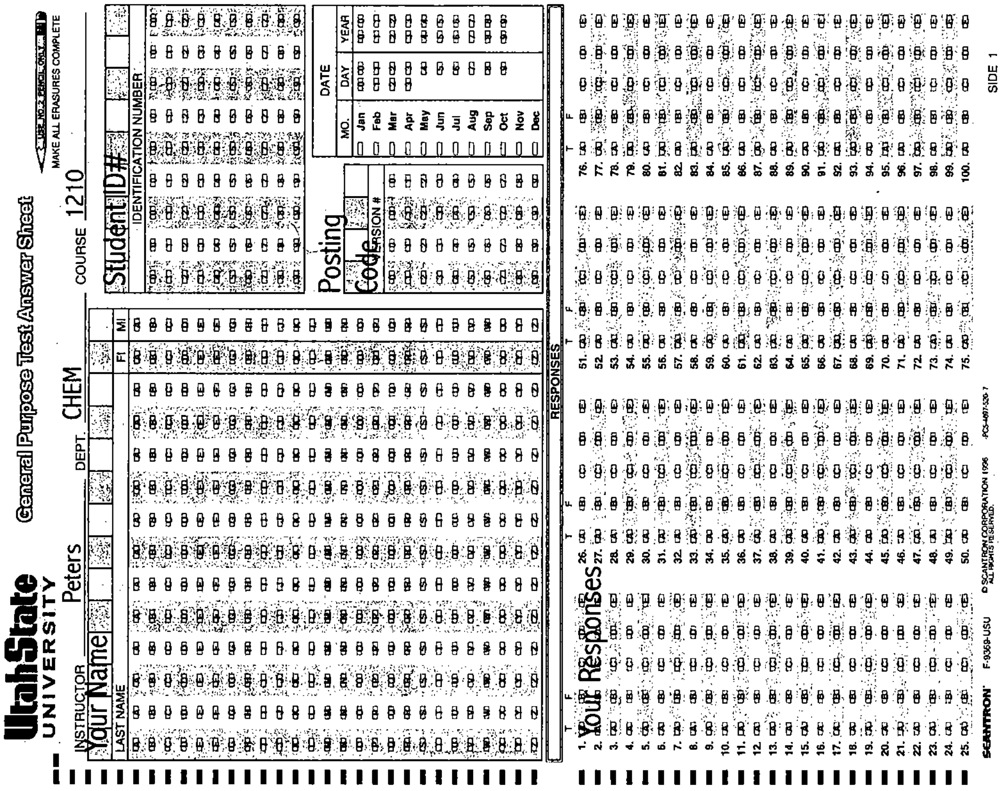
Keys

Chemistry 1220, Section 1
Second Hour Exam
March 8, 2002
Dr. Alexander I. Boldyrev

Instructions:

Do not begin until 8:30 AM. The exam must be turned in by 9:20 AM.

⇒ The exam has 25 questions. Each question is worth 4 points for a total of 100 points. A periodic table is located on the last page.
⇒ Use only a #2 pencil to mark the answer on the ScanTron sheet. You will turn in only the ScanTron sheet and you may keep the rest of the exam. Your exam results will be emailed to you. You can check your answers with the answer key that will be posted on-line on the next day after the exam.
⇒ On the ScanTron sheet print your name and identification number in the areas indicated. Indicate a four character code (any combination of letters and numbers) under "version#" for the purpose of reporting final grades.



Information

For the reaction aA + bB = cC + dD

$\Delta S^O=[cS^O(C) + dS^O(D)] - [aS^O(A) + bS^O(B)]$

$\Delta G^O=[c\Delta G_f^O(C) + d\Delta G_f^O(D)] - [a\Delta G_f^O(A) + b\Delta G_f^O(B)]$

$\Delta G=\Delta H-T\Delta S$

$\Delta G=\Delta G^O+RT\ln Q$ (R=8.314 J/mol-K)

$\Delta G^O=-RT\ln K$

$K = e^{-\Delta G^0 / RT}$

$pH=pK_a+\log([base]/[acid])$

$CaF_2 \rightarrow Ca^{+2} + 2F^-$ $\qquad K_{sp}=[Ca^{2+}][F^-]^2$

$K_a = \frac{[H^+][X^-]}{[HX]}, \; K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$

$K_a x K_b=K_w$, $pK_a + pK_b = pK_w= 14.00$

(1) Which salt if added to the solution will decrease the ionization of HOCl.

a) NaCl
[✓ b) KOCl]
c) $KClO_2$
d) $NaClO_4$
e) Na_2SO_4

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(2) Which mixture can function as a buffer?

a) HCl and KCl
b) H_2SO_4 and K_2SO_4
[✓ c) $HC_2H_3O_2$ and $NaC_2H_3O_2$] weak acid
d) H_2O and HCl
e) None of the above

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(3) Calculate the pH of a solution prepared by dissolving 0.37 mol of formic acid (HCO_2H) and 0.23 mol of sodium formate ($NaCO_2H$) in 1.00 L of solution ($K_a=1.8\text{x}10^{-4}$ for formic acid).

a) 2.09
b) 10.46
[✓ c) 3.54]
d) 2.30
e) 3.95

$$pH = pKa + \log \frac{[base]^{\,0.23M}}{[acid]_{\,0.37M}} = 3.74 - 0.20 = 3.54$$

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(4) What is the ratio of HCO_3^- to H_2CO_3 in an exhausted marathon runner whose blood pH is 7.1 ($K_a=4.3\text{x}10^{-7}$ for H_2CO_3)?

a) 2.1
b) 3.8
c) 10.5
d) -1.4
[✓ e) 5.4]

$$pH = pKa + \log \frac{[base]}{[acid]}$$

$$\log \frac{[base]}{[acid]} = pH - pKa = 7.1 - 6.37 = 0.73$$

$$\frac{[base]}{[acid]} = 10^{0.73} = 5.37$$

strong acid

(5) Consider the titration of 25.0 mL of 0.723 M HCl with 0.273 M KOH. The concentration of H^+ before any KOH is added is ___ M

a) 0.439
b) $1.00x10^{-7}$
[✓ c) 0.723]
d) $2.81x10^{-13}$
e) 0.273

$[H^+] = [HCl] = 0.723\ M$

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(6) Consider the titration of 25.0 mL of 0.723 M HCl with 0.273 M KOH. The concentration of H^+ after addition of 80.0 mL of KOH is ___ M

a) 0.439
b) $1.00x10^{-7}$
c) 0.723
[✓ d) $2.81x10^{-13}$]
e) 0.273

HCl : $0.0181\ mol = 0.723 \frac{mol}{L} \cdot 0.025L$

KOH : $0.0218\ mol = 0.273 \frac{mol}{L} \cdot 0.080L$ $[H^+][OH^-] = 1.0 \times 10^{-14}$

we have extra KOH $= 3.74 \times 10^{-3}$ mol

$[OH^-] = [KOH] = \frac{3.74 \times 10^{-3} mol}{0.105\ L} = 0.0356M$; $[H^+] = \frac{1.0 \times 10^{-14}}{0.0356} = 2.81 \times 10^{-13}$

strong base

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(7) An initial pH of 4.00, an equivalence point at pH 9.35, and a moderately short, nearly vertical middle section correspond to a titration curve for ___

a) strong acid titrated by strong base
b) strong base titrated by strong acid
[✓ c) weak acid titrated by strong base]
d) weak base titrated by strong acid
e) weak base titrated by weak acid

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(8) 50.50 mL of 0.116 M HF is titrated with 0.120 M NaOH. What is the pH after 50.50 mL of base have been added (K_a for HF is $6.8x10^{-4}$)

a) 7.000
[✓ b) 11.300]
c) 12.778
d) 8.119
e) 4.631

HF $5.858 \times 10^{-3}\ mol = 0.116 \frac{mol}{L} \times 0.0505L$

NaOH $6.060 \times 10^{-3}\ mol = 0.120 \frac{mol}{L} \times 0.0505L$

we have extra NaOH $= 2.02 \times 10^{-4}$ mol

$[OH^-] = [NaOH] = \frac{2.02 \times 10^{-4}\ mol}{0.101\ L} = 2.0 \times 10^{-3} M$

$pOH = -\log(2 \times 10^{-3}) = 2.70$

$pH = 14.00 - 2.70 = 11.30$

(9) Given the following table of K_{sp} values determine which compound listed has the greatest solubility.

Compound	K_{sp}
$CdCO_3$	$5.2x10^{-12}$
$Cd(OH)_2$	$2.5x10^{-14}$
AgI	$8.3x10^{-17}$
$Fe(OH)_3$	$4x10^{-38}$
$ZnCO_3$	$1.4x10^{-11}$

a) $CdCO_3$ solubility $= [Cd^{2+}] = \sqrt{[Cd^{2+}][CO_3^{2-}]} = 2.28 \times 10^{-6}$ M

[✓ b) $Cd(OH)_2$] solubility $= [Cd^{2+}] = \sqrt[3]{[Cd^{2+}][2OH^-]^2} = 1.84 \times 10^{-5}$ M

c) AgI solubility $= [Ag^+] = \sqrt{[Ag^+][I^-]} = 9.0 \times 10^{-9}$ M

d) $Fe(OH)_3$ solubility $= [Fe^{3+}] = \sqrt[4]{[Fe^{3+}][3OH^-]} = 2.58 \times 10^{-10}$

e) $ZnCO_3$

solubility $= [Zn^{2+}] = \sqrt{[Zn^{2+}][CO_3^{2-}]} = 3.74 \times 10^{-6}$

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(10) Of the substances below, _____ will decrease the solubility of $Pb(OH)_2$ in a saturated solution

a) $NaNO_3$
b) H_2O_2
c) HNO_3
[✓ d) $Pb(NO_3)_2$]
e) NaCl

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(11) The region of the atmosphere closest to the surface of the earth is called the ____

a) mesosphere
b) stratosphere
c) thermosphere
[✓ d) troposphere]
e) tropopause

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(12) Ozone is

a) O
b) O_2
[✓ c) O_3]
d) O_4
e) H_2O_2

(13) CFC stands for

a) chlorinated freon compound
[✓ b) chlorofluorocarbon]
c) carbonated fluorine compound
d) caustic fluorine carbohydrate
e) carbofluoro compound

(14) Natural, unpolluted rainwater is typically acidic. What is the source of this natural acidity?

[✓ a) CO_2]
b) O_2
c) NO_2
d) HCl
e) chlorofluorocarbons

(15) The concentration of which greenhouse gas has increased steadily over the last few decades?

a) NO_2
b) N_2O_4
c) CO
d) SO_2
[✓ e) CO_2]

(16) A reaction that is spontaneous, ____

a) will be very rapid as written
[✓ b) will proceed as written without outside intervention]
c) is also spontaneous in the reverse direction
d) has an equilibrium position that lies very far to the left
e) will occur very slowly

(17) Of the following, only ____ is not a state function.

a) S
b) H
[✓ c) w]
d) E
e) T

(18) Which one of the following reactions would have a positive value for ΔS^o?

a) $Ba(OH)_2$ (s) + CO_2 (g) → $BaCO_3$ (s) + H_2O (l)
b) N_2 (g) + $3H_2$ (g) → $2NH_3$ (g)
[✓ c) $2SO_3$ (g) → $2SO_2$ (g) + O_2(g)]
d) $AgNO_3$ (aq) + HCl (aq) → AgCl (s) + HNO_3 (aq)
e) freezing water to form ice

(19) Consider a pure, crystalline solid being heated from absolute zero to some very high temperature. Which one of the following processes produces the greatest increase in the entropy of the substance?

a) melting the solid
b) heating the liquid
c) heating the gas
d) heating the solid
[✓ e) boiling the liquid]

(20) Given the following table of thermodynamic data,

Substance	S°
C_2H_2 (g)	200.8 J/mol-K
C_2H_4 (g)	219.4 J/mol-K
H_2 (g)	130.6 J/mol-K

Determine the ΔS° (in J/mol-K) for the reaction:
$C_2H_2 (g) + H_2 (g) \rightarrow C_2H_4 (g)$

[✓ a) -112.0]
b) -102.0
c) -232.5
d) +112.0
e) +102.0

$$\Delta S^o = S^o_{C_2H_4} - S^o_{C_2H_2} - S^o_{H_2} = -112.0$$

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(21) What can be said about a chemical system that has a free energy (ΔG) zero?

a) it is at absolute zero
b) its entropy is zero
[✓ c) it is at equilibrium]
d) the reaction is complete
e) the reaction is very fast

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(22) For the following reaction

$C_2H_6 (g) \rightarrow C_2H_4 (g) + H_2 (g)$

ΔH is 137 kJ and ΔS° is 120 J/K

this reaction will be:

a) spontaneous at all temperatures
[✓ b) spontaneous only at high temperature]
c) spontaneous only at low temperature
d) nonspontaneous at all temperatures
e) unreliable

$$\Delta G = \overset{\overset{\text{positive}}{\downarrow}}{\Delta H} - \underbrace{\overset{\overset{\text{positive}}{\downarrow}}{T\Delta S}}$$

$T\Delta S > \Delta H$ at high temperature

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(23) If ΔG° for a reaction is greater than zero, then ____.

a) K=0
b) K=1
c) K>1
[✓ d) K<1]
e) More information is needed.

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(24) Consider the reaction: $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

Given the following table of thermodynamic data, $\Delta G = \Delta H - T\Delta S$

Substance	ΔH_f°	S°
NH_3 (g)	-46.19 kJ/mol	192.5 J/mol-K
HCl (g)	-92.30 kJ/mol	186.69 J/mol-K
$NH_4Cl(s)$	-314.4 kJ/mol	94.6 J/mol-K

$\Delta H^\circ = \Delta H_f^\circ(NH_4Cl) - \Delta H_f^\circ(NH_3) - \Delta H_f^\circ(HCl) =$
$= -175.91 \frac{kJ}{mol}$

$\Delta S^\circ = S^\circ(NH_4Cl) - S^\circ(NH_3) - S^\circ(HCl) =$
$= -284.6\ J/mol\text{-}K$

Determine the value of K for the reaction at 25°C.

a) 150
[✓ b) $9.3x10^{15}$] $\Delta G = \Delta H^\circ - T\Delta S^\circ = -175.91 \frac{kJ}{mol} - \left(\frac{-284.6 \frac{J}{mol.K} . 1kJ}{1000\ J}\right) \cdot (298\,K) =$
c) $8.4x10^4$
d) $1.1x10^{-16}$ $= -91.099\ kJ/mol$
e) $1.4x10^8$ $K = e^{-\Delta G/RT} = 9.3 \times 10^{+15}$

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(25) The third law of thermodynamics states that:

[✓ a) the entropy of a pure crystalline substance at absolute zero (T=0 K) is zero]
b) the entropy of a pure crystalline substance is always more then zero
c) the entropy of a pure crystalline substance is negative
d) the entropy of a pure crystalline substance is increasing with temperature
e) the entropy is a state function