

KWANTLEN UNIVERSITY COLLEGE

DEPARTMENT OF CHEMISTRY

CHEM 1210 FINAL EXAMINATION

April 17, 2002

Time: 3 hours

TOTAL = 105 MARKS

NAME: _____

INSTRUCTIONS:

1. Read all questions thoroughly and answer each question completely. **ALL WORK MUST BE SHOWN IN ORDER TO RECEIVE ANY CREDIT.**
2. You will be allowed to use only the given sheet of thermodynamic equations.
3. Ensure that this exam paper has **58** questions.

ADDITIONAL INFORMATION:

Avogadro's number = 6.02×10^{23}

Faraday = 96485 Coulombs

$R = 0.08206 \text{ L-atm/mol-K} = 8.314 \text{ J/mol-K}$

Arrhenius equation: $k = Ae^{-E_a/RT}$

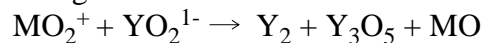
Nernst equation: $\varepsilon = \varepsilon^\circ - (0.05916/n)\log Q$ (at 25°C)

First order kinetics: $\ln(A_0/A) = kt$

Second order kinetics: $[1/A] - [1/A_0] = kt$

Freezing point depression and boiling point elevation: $\Delta T = iK_m$

1. **(5 Marks)** Balance the following oxidation-reduction reaction in basic solution:



2. **(2 Marks)** Under certain conditions oxidation of sodium azide (NaN_3 , molar mass = 65.01) results in the production of $\text{NO}_2(\text{g})$. What is the equivalent mass of sodium azide under these conditions?

3. For $2\text{A} + \text{B} \rightarrow \text{C}$, initial rate law data are:

Exp.	[A]	[B]	Rate
#1	0.10	0.10	2.0×10^{-3}
#2	0.30	0.10	18.0×10^{-3}
#3	0.20	0.30	24.0×10^{-3}

(2)

The rate law is $\text{Rate} = k[\text{A}]^x[\text{B}]^y$

- a. $x = 1$ and $y = 2$
- b. $x = 2$ and $y = 1$
- c. $x = 1$ and $y = 1$
- d. $x = 2$ and $y = 2$
- e. $x = 0$ and $y = 2$

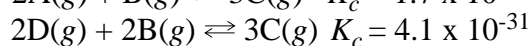
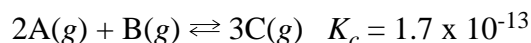
4. What are the units for the rate constant for the rate law $= k[\text{A}][\text{B}][\text{C}]$?

- a. $M^{-2}\text{-sec}$
- b. $M^{-1}\text{-sec}^{-1}$
- c. $M^2\text{-sec}^{-1}$
- d. $M^{-2}\text{-sec}^{-1}$
- e. $M^{-3}\text{-sec}^{-1}$

(1)

5. If the half-life of a reaction is found to be directly proportional to the concentration of a reactant, the reaction order is
- zero
 - first
 - second
 - third
 - none of these
- (1)
6. If a catalyst is added to a reaction
- the value of k is increased.
 - the value of k is decreased.
 - the rate is increased.
 - the rate is decreased.
 - neither rate nor the rate constant are changed, only the order.
- (1)
- a. 1 and 4 b. 2 and 4 c. 2 and 3 d. 1 and 3 e. only 5
7. Substance A decomposes by a first-order reaction. If $[A]_0 = 2.00\text{ M}$ and after 150 minutes $[A] = 0.25\text{ M}$, then its half life is:
- 300 minutes
 - 150 minutes
 - 75 minutes
 - 50 minutes
 - 37.5 minutes
- (2)
8. Which of the following statements is TRUE about the reaction $2A + B \rightarrow C$ which is first order in A and first order overall
- The rate of the reaction will decrease at higher concentrations of B
 - The time required for one half of A to react is directly proportional to the quantity of A present.
 - The rate of formation of C is twice the rate of reaction of A.
 - The rate of reaction of B is the same as the rate of reaction of A.
 - None of these.
- (2)
9. The half-life for a first order reaction is 12 hours at 35°C and 2.5 hours at 100°C . What is the activation energy for this reaction?
- 31.6 kJ/mol
 - 27.4 kJ/mol
 - 23.1 kJ/mol
 - 10.0 kJ/mol
 - 27.4 kJ/mol
- (2)
10. Consider the following hypothetical equilibrium:
- $$B_2(g) + A_2(g) \rightleftharpoons 2AB(g) \text{ where } K_c = 4$$
- What is the value of K_c for the equilibrium:
- $$4AB(g) \rightleftharpoons 2B_2(g) + 2A_2(g)$$
- 0.5
 - 0.25
 - 2
 - 0.0625
 - 16
- (2)

11. Given the following equilibria:



Find the equilibrium constant for the following equilibrium: $2D(g) + B(g) \rightleftharpoons 2A(g)$

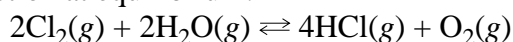
- a. 1.6×10^{-9}
b. 7.0×10^{-44}
(2) c. 2.6×10^{-22}
d. 4.2×10^{17}
e. 2.4×10^{-18}

12. For the reaction: $POCl_3(g) \rightleftharpoons POCl(g) + Cl_2(g)$, $K_c = 0.450$

A sample of pure $POCl_3(g)$ was placed in a container and allowed dissociate according to the above reaction. At equilibrium, the concentration of $POCl(g)$ was found to be $0.150 M$. What was the initial concentration of $POCl_3(g)$?

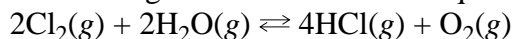
- a. $0.225 M$
b. $0.200 M$
(2) c. $0.633 M$
d. $0.483 M$
e. $0.350 M$

13. For the following chemical reaction at equilibrium:



- a. $K_p = K_c$
(2) b. $K_p = K_c(RT)$
c. $K_p = K_c(RT)^{-1}$
d. $K_p = K_c(RT)^{-3}$
e. $K_p = K_c(RT)^3$

14. Calculate the ratio (K_p/K_c) for the following chemical reaction at equilibrium at $25^\circ C$:



- a. 1
(1) b. 24.5
c. 2.05
d. 0.0408
e. 2477

15. Consider the equilibrium:



The equilibrium is shifted to the left if:

- a. some sulfur trioxide is removed.
b. the temperature is raised.
(2) c. a catalyst is added.
d. the pressure is raised.
e. none of these answers.

16. All of the following may shift the position of a reaction at equilibrium **EXCEPT**:

- a. temperature change
b. concentration change
(1) c. volume change
d. pressure change
e. catalyst

17. For the reaction: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
In a closed 3.0 liter container are placed 0.75 mol of N_2 and 1.20 mol of H_2 . When the reaction reaches equilibrium, $[\text{H}_2] = 0.100 \text{ M}$. Which of the following is TRUE?
- $[\text{NH}_3] = 0.150 \text{ M}$
 - $[\text{NH}_3] = 0.200 \text{ M}$
 - $[\text{N}_2] = 0.650 \text{ M}$
 - $[\text{N}_2] = 0.250 \text{ M}$
 - none of these
- (2)
18. In the equilibrium system: $\text{PO}_4^{3-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HPO}_4^{2-}(\text{aq}) + \text{OH}^-(\text{aq})$
Brønsted-Lowry theory would designate:
- PO_4^{3-} and H_2O as the bases
 - HPO_4^{2-} and PO_4^{3-} as a conjugate pair
 - HPO_4^{2-} as a base
 - HPO_4^{2-} and H_2O as a conjugate pair
 - PO_4^{3-} as amphiprotic
- (1)
19. Which species in the following reaction acts as the Lewis acid?
 $\text{Co}^{2+}(\text{aq}) + 4\text{Cl}^-(\text{aq}) \rightleftharpoons \text{CoCl}_4^{2-}(\text{aq})$
- CoCl_4^{2-}
 - Cl^-
 - Co^{2+}
 - none are acids
- (1)
20. 0.272 g of a monoprotic acid (Molar mass = 189 g/mol) is dissolved in water to produce 25.0 mL of a solution with pH = 4.93. Calculate the dissociation constant of the acid.
- 4.1×10^{-8}
 - 1.4×10^{-10}
 - 2.1×10^{-4}
 - 2.8×10^{-7}
 - 2.4×10^{-9}
- (2)
21. Determine the pH of the solution prepared by mixing equal amounts of 0.210 M HCl and 1.63 M NaCHO_2 . $K_a(\text{for HCHO}_2) = 1.8 \times 10^{-4}$.
- 2.91
 - 4.57
 - 4.77
 - 9.43
 - 11.09
- (2)
22. Which of the following would NOT be considered a buffer solution?
- 0.1 M $\text{HC}_2\text{H}_3\text{O}_2$ and 0.1 M $\text{NaC}_2\text{H}_3\text{O}_2$
 - 0.1 M NH_3 and 0.1 M NH_4NO_3
 - 0.1 M NaHSO_3 and 0.1 M H_2SO_3
 - 0.1 M HI and 0.1 M NaI
 - 0.1 M Na_2HPO_4 and 0.1 M NaH_2PO_4
- (1)

23. In the titration of 20.0 mL of a 0.100 M H_2A acid ($\text{p}K_{a1} = 4.00$ and $\text{p}K_{a2} = 6.00$) with 0.200 M NaOH. Which of the following is FALSE?
- 20.0 mL of NaOH solution are needed to reach the second equivalence point.
 - the pH at the first equivalence point is 5.00
 - (4) the pH at the second equivalence point is greater than 7.0
 - when 10.0 mL of NaOH have been added the $[\text{H}_2\text{A}] = [\text{HA}^-]$
 - At the start before any base has been added the pH = 2.50
24. What is the after addition of 10.0 mL of 1.0 M HCl to 90.0 mL of a buffer consisting of 1.0 M NH_3 and 1.0 M NH_4Cl ?
 $K_b(\text{for ammonia}) = 1.8 \times 10^{-5}$
- 4.74
 - 9.16
 - (2) 9.26
 - 9.36
 - 11.58
25. A certain acid has a $K_a = 6.80 \times 10^{-6}$. What is the pH of a 0.247 M solution of the acid's potassium salt?
- 4.72
 - 9.28
 - (2) 9.11
 - 9.44
 - 9.89
26. For aqueous NH_4NO_3 , predict whether the solution is acidic, basic or neutral and why.
- acidic because it is a strong acid.
 - basic because it is a weak base.
 - (1) neutral because there is no hydrolysis.
 - acidic because it is the salt of a strong acid.
 - acidic because it is the salt of a weak base.
27. Phenol red indicator changes from yellow to red in the pH range 6.6 to 8.0. What color will the indicator show in a 0.10 M NaCN solution?
- red
 - yellow
 - (1) c. red-yellow mixture
 - the indicator is its original color
 - there is not enough information to answer this question.
28. What is the concentration of SO_4^{2-} ion in a 3.6 M H_2SO_4 solution?
 $K_{a2} = 1.1 \times 10^{-2}$.
- 0.011 M
 - 0.040 M
 - (2) 0.20 M
 - 0.60 M
 - 1.8 M

29. Ten mL of 0.10 M $\text{NH}_3(aq)$ ($K_b = 1.8 \times 10^{-5}$) is mixed with ten mL of 0.10 M NH_4Cl , the resulting solution:
- has a pH = 4.74
 - has a $[\text{H}^+]$ of about $1 \times 10^{-3} M$
 - is acidic
 - has an $[\text{OH}^-]$ of about $1.8 \times 10^{-5} M$
 - has an $[\text{NH}_4^+]$ greater than that of the $\text{NH}_4\text{Cl}(aq)$
- (2)
30. The $\text{p}K_b$ for methylamine is 3.38. What is the pH of an aqueous solution for which the label reads 0.042 M CH_3NH_2 ?
- 2.4
 - 4.8
 - 9.2
 - 11.6
 - 12.3
- (2)
31. Which of the following has the smallest molar solubility in pure water?
- CuS ($K_{sp} = 8 \times 10^{-37}$)
 - Bi_2S_3 ($K_{sp} = 1 \times 10^{-70}$)
 - Ag_2S ($K_{sp} = 6 \times 10^{-51}$)
 - MnS ($K_{sp} = 7 \times 10^{-16}$)
 - PbS ($K_{sp} = 3 \times 10^{-28}$)
- (3)
32. Calculate the molar solubility of silver chromate in a 0.010 M Na_2CrO_4 solution. K_{sp} of $\text{Ag}_2\text{CrO}_4 = 9.0 \times 10^{-12}$.
- $9.0 \times 10^{-10} M$
 - $4.5 \times 10^{-10} M$
 - $6.0 \times 10^{-5} M$
 - $3.0 \times 10^{-5} M$
 - $1.5 \times 10^{-5} M$
- (2)
33. The solubility product of silver sulfate is 1.6×10^{-5} . What is the molar solubility of this compound in pure water?
- $8^{\frac{1}{2}} \times 10^{-2} M$
 - $4^{\frac{1}{3}} \times 10^{-2} M$
 - $16^{\frac{1}{2}} \times 10^{-3} M$
 - $1.6 \times 10^{-5} M$
 - none of these M
- (2)
34. The heat of combustion, $\Delta H^\circ_{\text{comb}}$, for one mole of benzene (C_6H_6) is -3267.4 kJ. Given the $\Delta H^\circ_f(\text{CO}_2(g)) = -393.5 \text{ kJ/mol}$ and $\Delta H^\circ_f(\text{H}_2\text{O}(l)) = -285.8 \text{ kJ/mol}$.
- $$\text{C}_6\text{H}_6(l) + 15/2 \text{ O}_2(g) \rightarrow 6\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$$
- Calculate the ΔH°_f of benzene.
- +2588.1 kJ/mol
 - 49.0 kJ/mol
 - 808.4 kJ/mol
 - +49.0 kJ/mol
 - +808.4 kJ/mol
- (2)

35. For the reaction $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$ $\Delta H^\circ = -483.6 \text{ kJ}$
What mass of $\text{H}_2(\text{g})$ is required to liberate 1000 kJ of heat?
- (2) a. 66.2 g
b. 2.05 g
c. 4.17 g
d. 8.34 g
e. 16.7 g
36. Choose the correct statements concerning entropy.
- (1) (1) As two gases mix, ΔS is positive.
(2) Entropy is a thermodynamic property related to the degree of disorder.
(2) (3) As temperature in a gas decreases, ΔS is positive.
(4) Molecules in the liquid state have higher entropy than molecules in the gaseous state.
- a. 1 and 3 b. 1,2 and 3 c. 1 and 2 d. 1,2 and 4 e. 2 and 3
37. Which of the following combinations of signs for ΔH° and ΔS° will always result in a reaction being spontaneous?
- (1) a. $\Delta H^\circ(+)$ and $\Delta S^\circ(+)$
b. $\Delta H^\circ(+)$ and $\Delta S^\circ(-)$
c. $\Delta H^\circ(-)$ and $\Delta S^\circ(+)$
d. $\Delta H^\circ(-)$ and $\Delta S^\circ(-)$
e. cannot determine without the temperature
38. Calculate the entropy change for methanol at its normal boiling point of 64.5°C . The molar enthalpy of vaporization of methanol is 38.0 kJ/mol .
- (1) a. must know ΔG to calculate
b. 112 kJ/mol-K
c. 589 kJ/mol-K
d. 0.589 kJ/mol-K
e. 0.112 kJ/mol-K
39. For a particular reaction $K_p = 0.377$ at 25°C . What is ΔG° for this reaction?
- (1) a. 88.02 J/mol
b. 202.7 J/mol
c. 1049 J/mol
d. 2420 J/mol
e. -1049 J/mol
40. For the reaction: $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$. What is ΔS° for the system?
- (2) a. $+605 \text{ J/K}$
b. $+137 \text{ J/K}$
c. $+12 \text{ J/K}$
d. -39 J/K
e. -183 J/K

41. For the reaction: $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$ at 298 K. Which of the following statements is TRUE?
- $\Delta S_{\text{universe}} > 0$ and $\Delta G^\circ < 0$
 - $\Delta S_{\text{universe}} < 0$ and $\Delta G^\circ > 0$
 - $\Delta S_{\text{universe}} = 0$ and $\Delta G^\circ = 0$
 - $\Delta S_{\text{universe}} > 0$ and $\Delta S_{\text{surroundings}} = 0$
 - $\Delta S_{\text{universe}} < 0$ and $\Delta S_{\text{system}} > 0$
- (2)
42. For the reaction $\text{Cl}_2(\text{g}) + 3\text{F}_2(\text{g}) \rightleftharpoons 2\text{ClF}_3(\text{g})$ $K_p = 4.1 \times 10^{34}$ at 77°C and $K_p = 1.3 \times 10^{43}$ at 25°C . What is the value of ΔH° ?
- +157 kJ
 - 157 kJ
 - 6.0 kJ
 - 142 kJ
 - 326 kJ
- (2)
43. Consider the reaction:
- | | | | | |
|---|-----------------------|---------------------------|----------------------|----------------------------------|
| | $\text{CO}(\text{g})$ | $+ 2\text{H}_2(\text{g})$ | \rightleftharpoons | $\text{CH}_3\text{OH}(\text{g})$ |
| $\Delta H_{f,298}^\circ(\text{kJ/mol})$ | -110.5 | 0 | | -200.7 |
| $S^\circ(\text{J/mol-K})$ | 197.6 | 130.6 | | 239.7 |
- What is ΔG° for this reaction at 300°C ? Is the reaction spontaneous at 300°C ?
- 35.3 kJ, YES
 - +35.3 kJ, NO
 - +35.3 kJ, YES
 - 24.5 kJ, NO
 - 24.5 kJ, YES
- (2)
44. Determine the equilibrium constant (K_c) for the following reaction at 298 K:
- $$\text{Sn}^{2+}(\text{aq}) + \text{Ti}(\text{s}) \rightarrow \text{Sn}(\text{s}) + \text{Ti}^{2+}(\text{aq})$$
- Given the standard reduction potentials: $\text{Ti}^{2+}/\text{Ti} = -1.630 \text{ V}$ and for $\text{Sn}^{2+}/\text{Sn} = -0.137 \text{ V}$
- 1.7×10^{25}
 - 3.0×10^{50}
 - 5.4×10^{59}
 - 3.4×10^{-51}
 - 1.8×10^{-60}
- (2)
45. Will magnesium metal react with Al^{3+} ion from an aqueous solution? The standard reduction potentials: $\text{Mg}^{2+}/\text{Mg} = -2.36 \text{ V}$ and for $\text{Al}^{3+}/\text{Al} = -1.68 \text{ V}$
- no, since the cell voltage is negative
 - yes, since ΔG° is positive
 - yes, because the system is at equilibrium
 - yes, since $\Delta S_{\text{universe}} > 0$
 - no, because the reverse reaction is spontaneous
- (2)
46. Choose the INCORRECT statement:
- An electrode is often a strip of metal.
 - An electrode in a solution of its ions is a half cell.
 - An electrochemical cell is a half-cell.
 - The electromotive force (emf) is the cell potential.
 - The cell potential is the potential difference between the half-cells.
- (1)

47. A copper electrode weighs 23.07 g before the electrolysis of a CuSO_4 solution and 24.34 g after the electrolysis has run using a current of 193 ampere. What was the time for this electrolysis?
- 10 seconds
 - 20 seconds
 - 40 seconds
 - 60 seconds
 - 80 seconds
- (2)
48. Choose the FALSE statement:
- Only spontaneous processes occur naturally.
 - The entropy of vaporization is always positive.
 - The combustion of any hydrocarbon is exothermic.
 - ΔG° is always equal to zero at equilibrium.
 - The greater the degree of randomness in a system, the greater the entropy of the system.
- (2)
49. Calculate ϵ_{cell} for the following voltaic cell at 298 K:
- $$\text{Ni}(s) | \text{Ni}^{2+}(aq) [\text{saturated NiCO}_3(s)] || \text{Ni}^{2+}(0.010 M) | \text{Ni}(s)$$
- The K_{sp} for NiCO_3 is 1.42×10^{-7} and the standard reduction potential for $\text{Ni}^{2+}/\text{Ni} = -0.257 \text{ V}$.
- +0.257 V
 - 0.0422 V
 - 0.000 V
 - +0.0844 V
 - +0.0422 V
- (2)
50. What is ϵ° for the reaction: $\text{CH}_3\text{OH}(l) + 3/2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$ if the $\Delta G^\circ = -702.5 \text{ kJ}$?
- +0.91 V
 - +1.21 V
 - +1.82 V
 - +3.64 V
 - 1.82 V
- (2)
51. Which probably has the highest boiling point at 1.00 atm pressure?
- CH_3NH_2
 - $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 - CH_3OH
 - $(\text{CH}_3)_2\text{N}(\text{CHF}_2)$
 - C_4H_{10}
- (1)
52. If a substance has a heat of vaporization of 3.46 kJ/g and a heat of sublimation of 4.60 kJ/g, what is its heat of fusion?
- 1.14 kJ/g
 - 8.06 kJ/g
 - 1.14 kJ/g
 - 8.06 kJ/g
 - none of these
- (1)

53. The triple point of water is at 4.58 mm Hg and $+0.01^{\circ}\text{C}$. Some H_2O at -50°C is heated to 120°C at a constant pressure of 2.05 mm Hg. The changes of state(s) occurring in this process are:
- a. solid to gas
 - b. solid to liquid to gas
 - (1) c. liquid to gas
 - d. solid to liquid
 - e. no change in state occurs at constant pressure
54. The normal boiling point of ethanol is 78.3°C and $\Delta H^{\circ}_{\text{vap}} = 39.3 \text{ kJ/mol}$. What is the vapor pressure of ethanol at 50.0°C ?
- a. 118 mm Hg
 - b. 234 mm Hg
 - (2) c. 354 mm Hg
 - d. 485 mm Hg
 - e. 670 mm Hg
55. The vapor pressure of pure hexane at 25°C is 151.4 mm Hg and for heptane it is 45.6 mm Hg. A solution contains 0.800 mol fraction hexane. What is the composition of the vapor in equilibrium with this solution at 25°C ?
- a. 80.0% hexane and 20.0% heptane
 - (2) b. 50.0% hexane and 50.0% heptane
 - c. 77.0% hexane and 23.0% heptane
 - d. 45.0% hexane and 55.0% heptane
 - e. 93.0% hexane and 7.0% heptane
56. A solution composed of 5 mol acetone (CH_3COCH_3 , $P^{\circ} = 324 \text{ mm Hg}$) and 5 moles of chloroform (CHCl_3 , $P^{\circ} = 274 \text{ mm Hg}$) has a vapor pressure of 236 mm Hg. Which one of the following statements is completely true about this solution?
- a. The solution obey's Raoult's Law.
 - b. The solution shows a positive deviation from Raoult's Law.
 - (2) c. The solution shows a negative deviation from Raoult's Law and possesses a minimum boiling point azeotrope.
 - d. The solution shows a negative deviation from Raoult's Law and possesses a maximum boiling point azeotrope.
 - e. The solution process is exothermic because the forces between unlike molecules are weaker than those between like molecules.
57. An aqueous NaCl solution freezes at -1.13°C . Calculate the approximate NaCl concentration of this solution in % by mass. K_f for water is $1.86^{\circ}\text{C}\cdot\text{m}^{-1}$.
- a. 3.55%
 - b. 1.78%
 - (2) c. 0.870%
 - d. 17.8%
 - e. 8.90%
58. Solutions are made that contain 0.10 mol of each of the following compounds below in 100 g of water. Choose the compound whose solution will have the lowest freezing point.
- (2) a. BaBr_2 b. KCl c. CH_3OH d. NiSO_4 e. H_2SO_4