

CHEMISTRY 16

FINAL EXAM

Dr. M. Richards-Babb

August 7, 1998
(Version I)

An optical scoring machine will grade this examination. The machine is not programmed to accept the correct one of two sensed answers and will not sense answers which are lightly marked. Mark your answer sheet carefully with a No. 2 soft lead pencil and erase any undesired marks COMPLETELY. Avoid making any extraneous marks on the answer sheet other than the information requested below.

On the answer sheet:

1. Print your name in the space for NAME (last name first, circle your last name).
2. In the space marked SUBJECT print your student number.
3. In the space marked HOUR print Summer II '98.

Check to see that you have 50 examination questions, periodic table and scratch paper when the exam begins.

HAND IN ONLY THE ANSWER SHEET.

Useful Equations and Constants:

$$1C \times V = 1 J$$

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

$$F = 96,500 \text{ C/mol } e^-$$

$$K_w = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$K_f(\text{H}_2\text{O}) = 1.86 \text{ kg-}^\circ\text{C/mol}$$

$$K_b(\text{H}_2\text{O}) = 0.52 \text{ kg-}^\circ\text{C/mol}$$

$$x = \frac{-b \pm (b^2 - 4ac)^{1/2}}{2a}$$

$$\ln[A] = \ln[A]_0 - kt \quad \text{OR} \quad \log[A] = \log[A]_0 - kt/2.303$$

$$[A]/[A]_0 = \exp(-kt)$$

$$1/[A] = 1/[A]_0 + kt$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

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

$$\Delta G^\circ = -nFE^\circ$$

$$E = E^\circ - (RT/nF) \ln Q$$

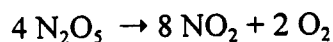
1. If 0.0339 mol of a nonelectrolyte is dissolved in 0.0550 kg of benzene C_6H_6 , the freezing point of the resulting solution is:
($K_f(C_6H_6)=5.12 \text{ kg}\cdot^\circ\text{C}/\text{mol}$; $T_f(C_6H_6)=+5.48^\circ\text{C}$)

- A. $+8.64^\circ\text{C}$
- B. $+4.66^\circ\text{C}$
- C. -1.57°C
- D. $+2.32^\circ\text{C}$
- E. -3.61°C

2. C_4H_8 decomposes by first order kinetics with $k=9.2\times 10^{-3} \text{ sec}^{-1}$ at 500°C . How long will it take for a 0.100 M sample of C_4H_8 to decompose to 20% of its original value at 500°C ?

- A. 175 sec
- B. 21 sec
- C. 110 sec
- D. 250 sec
- E. 57 sec

3. Refer to the reaction below. If the rate of disappearance of N_2O_5 is $6.0\times 10^{-3} \text{ M}/\text{sec}$, then the rate of appearance of NO_2 is:

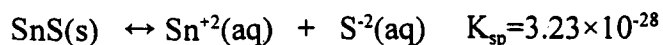


- A. $3.0\times 10^{-3} \text{ M}/\text{sec}$
 - B. $6.0\times 10^{-3} \text{ M}/\text{sec}$
 - C. $1.2\times 10^{-2} \text{ M}/\text{sec}$
 - D. $4.8\times 10^{-2} \text{ M}/\text{sec}$
 - E. Not enough information is given to answer this question.
4. The pH of apples is 3.10. The concentration of hydronium ion H_3O^+ in apples is:
- A. $7.9\times 10^{-4} \text{ M}$
 - B. $6.5\times 10^{-12} \text{ M}$
 - C. $1.0\times 10^{-7} \text{ M}$
 - D. $3.1\times 10^{-9} \text{ M}$
 - E. $1.3\times 10^{-11} \text{ M}$

5. The pH of 0.0025 M NaOH is:

- A. 2.60
- B. 11.70
- C. 11.40
- D. 9.86
- E. 7.25

6. SnS has $K_{sp}=3.23 \times 10^{-28}$. Addition of HCl will _____ the solubility of SnS in water, while addition of K_2S will _____ the solubility.



- A. increase; decrease
B. increase; increase
C. decrease; decrease
D. decrease; increase
E. not alter; decrease
7. A certain reaction is endothermic ($\Delta H=+$) and entropy is decreasing ($\Delta S=-$) from reactants to products. Which one of the following statements pertaining to the reaction spontaneity is TRUE?
- A. The reaction is spontaneous at all temperatures.
B. The reaction is nonspontaneous at low temperatures but spontaneous at high temperatures.
C. The reaction is nonspontaneous at all temperatures.
D. The reaction is spontaneous at low temperatures but nonspontaneous at high temperatures.
E. There is no way to decide without the value for ΔG .
8. Sodium reacts violently with water according to the equation:
$$2 \text{Na}(s) + 2 \text{H}_2\text{O}(l) \rightarrow 2 \text{NaOH}(aq) + \text{H}_2(g)$$

The resulting solution has a higher temperature than the water prior to the addition of sodium. The signs for ΔH° and ΔS° are:
- A. ΔH° is positive and ΔS° is positive.
B. ΔH° is negative and ΔS° is positive.
C. Not enough information given. Need standard heats of formation and molar entropies to calculate ΔH° and ΔS° .
D. ΔH° is positive and ΔS° is negative.
E. ΔH° is negative and ΔS° is negative.
9. Calculate ΔS° for the following reaction:
$$\text{N}_2(g) + 2 \text{O}_2(g) \rightarrow 2 \text{NO}_2(g)$$

given
 $S^\circ(\text{N}_2(g))=191.5 \text{ J/K-mol}$
 $S^\circ(\text{O}_2(g))=205.0 \text{ J/K-mol}$
 $S^\circ(\text{NO}_2(g))=240.0 \text{ J/K-mol}$
- A. -156.5 J/K
B. -121.5 J/K
C. +15.5 J/K
D. +636.5 J/K
E. -313.0 J/K

10. For the reaction $3 \text{C}_2\text{H}_2(\text{g}) \rightarrow \text{C}_6\text{H}_6(\text{l})$ $\Delta G^\circ = -503 \text{ kJ}$, the equilibrium constant K at 25°C is:

- A. 4.93×10^{-3}
- B. 1.48×10^{88}
- C. 5.71×10^{10}
- D. 6.74×10^{-89}
- E. 1.23

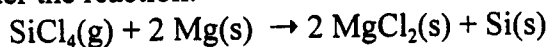
11. Consider the reaction:



Calculate ΔG° at 500K and state whether the equilibrium composition should favor reactants or products at 500 K.

- A. -110 kJ; reactants are favored
- B. $+1.39 \times 10^5$ kJ; reactants are favored
- C. -388 kJ; products are favored
- D. -110 kJ; products are favored
- E. -139 kJ; products are favored

12. Consider the reaction:



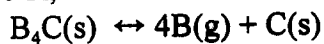
Calculate ΔG° at 25°C given the values below:

$$\Delta G_f^\circ(\text{SiCl}_4(\text{g})) = -620. \text{ kJ/mol}$$

$$\Delta G_f^\circ(\text{MgCl}_2(\text{s})) = -592. \text{ kJ/mol}$$

- A. -564 kJ
- B. +28 kJ
- C. +385 kJ
- D. -1212 kJ
- E. -28 kJ

13. At 2600 K, $\Delta G^\circ = +775 \text{ kJ}$ for the reaction below:

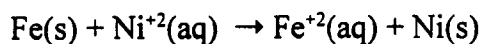


If the partial pressure of the gaseous boron $\text{B}(\text{g})$ is 1.0×10^{-5} atm over a mixture of the two solids, ΔG at 2600 K is _____ and the reaction is _____ in the forward direction.

- A. -220. kJ; spontaneous
- B. -270 kJ; spontaneous
- C. -220 kJ; nonspontaneous
- D. +114 kJ; spontaneous
- E. +746 kJ; nonspontaneous

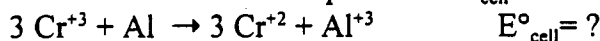
14. A galvanic cell _____.
- A. uses electrical energy to drive a nonspontaneous chemical reaction.
 - B. does not involve a redox reaction.
 - C. has $E^\circ_{\text{cell}}=0$
 - D. converts chemical energy of a spontaneous chemical reaction into electricity.
 - E. has $E^\circ_{\text{cell}} < 0$.

15. The net cell reaction for a galvanic cell is:



The shorthand notation for this cell is:

- A. $\text{Fe(s)}|\text{Ni}^{2+}(\text{aq})||\text{Fe}^{2+}(\text{aq})|\text{Ni(s)}$
 - B. $\text{Fe(s)}|\text{Fe}^{2+}(\text{aq})||\text{Ni}^{2+}(\text{aq})|\text{Ni(s)}$
 - C. $\text{Ni(s)}|\text{Fe}^{2+}(\text{aq})||\text{Ni}^{2+}(\text{aq})|\text{Fe(s)}$
 - D. $\text{Ni(s)}|\text{Ni}^{2+}(\text{aq})||\text{Fe}^{2+}(\text{aq})|\text{Fe(s)}$
 - E. $\text{Fe(s)}|\text{Ni(s)}||\text{Ni}^{2+}(\text{aq})|\text{Fe}^{2+}(\text{aq})$
16. Determine the standard net cell potential E°_{cell} for the following net cell reaction



given

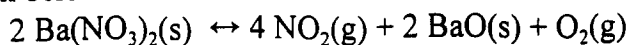


- A. -2.07 V
 - B. +1.25 V
 - C. -0.43 V
 - D. +0.43 V
 - E. +0.14 V
17. The standard net cell potential E°_{cell} for the reaction below is +0.19 V.
- $$\text{Ni}^{2+} + \text{Fe(s)} \rightarrow \text{Fe}^{2+} + \text{Ni(s)} \quad E^\circ_{\text{cell}} = +0.19 \text{ V}$$
- The standard Gibbs free energy ΔG° (in units of kJ) for this reaction is:
- A. -37 kJ
 - B. -254 kJ
 - C. +18 kJ
 - D. -73 kJ
 - E. -18 kJ

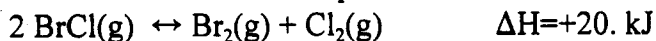
18. Which of the following conditions does NOT specify a spontaneous reaction in the forward direction?
- A. $\Delta S_{\text{total}} < 0$
 - B. $Q < K$
 - C. $E^{\circ}_{\text{cell}} > 0$
 - D. $\Delta G^{\circ} < 0$
 - E. All of the above specify nonspontaneous reactions.
19. Which of the following acts as a weak electrolyte when dissolved in water?
- A. $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ (sugar)
 - B. KOH
 - C. HNO_3
 - D. $\text{HC}_2\text{H}_3\text{O}_2$
 - E. KBr
20. The conjugate base of HCO_3^- is _____ while the conjugate acid of H_2O is _____.
- A. H_2CO_3 ; OH^-
 - B. OH^- ; H_3O^+
 - C. CO_3^{2-} ; H_3O^+
 - D. CO_2 ; H^+
 - E. None of the above is correct.
21. When HCl is added to a HF/NaF buffer the _____ from the HCl will neutralize the _____ of the buffer.
- A. H_3O^+ ; HF
 - B. Cl^- ; Na^+
 - C. OH^- ; HF
 - D. H_3O^+ ; OH^-
 - E. H_3O^+ ; F^-
22. The pH of a buffer containing 1.5 M HNO_2 and 0.50 M NaNO_2 is:
 $K_A(\text{HNO}_2) = 4.6 \times 10^{-4}$
- A. 3.34
 - B. 11.14
 - C. 1.76
 - D. 3.90
 - E. 2.86

23. Which of the indicators below should be used to detect the endpoint in a titration of $\text{HC}_2\text{H}_3\text{O}_2$ with NaOH ?
- | | | | |
|----|---------------------------------------|---------|------------------|
| A. | Methyl green | 0.2-1.8 | yellow to blue |
| B. | Ethyl red | 4.0-5.8 | colorless to red |
| C. | Bromothymol blue | 6.0-7.6 | yellow to blue |
| D. | Thymol blue | 8.2-9.8 | colorless to red |
| E. | Any of the indicators in A-D will do. | | |
24. Which one of the following dissolves in water to give a neutral solution?
- A. AlCl_3
B. NaClO_4
C. NaOH
D. NH_4Br
E. $\text{NaC}_2\text{H}_3\text{O}_2$
25. Addition of which of the following to an aqueous solution saturated with Ag_2SO_4 ($K_{sp} = 1.19 \times 10^{-5}$) will increase the solubility of the Ag_2SO_4 ?
- A. HCl
B. Na_2SO_4
C. AgNO_3
D. NH_3
E. All will increase the solubility of Ag_2SO_4 .
26. The molar solubility of Ag_3PO_4 in pure water is:
 $K_{sp}(\text{Ag}_3\text{PO}_4) = 1.05 \times 10^{-16}$
- A. $1.97 \times 10^{-9} \text{ M}$
B. $3.89 \times 10^{-18} \text{ M}$
C. $1.05 \times 10^{-16} \text{ M}$
D. $2.86 \times 10^{-6} \text{ M}$
E. $4.44 \times 10^{-5} \text{ M}$
27. The only factor which will change the value of the equilibrium constant K is:
- A. an increase in product concentrations.
B. a decrease in reactant concentrations.
C. An increase or decrease in volume.
D. an increase or decrease in temperature.
E. the addition of a catalyst.

28. The equilibrium constant expression for the decomposition of barium nitrate by the reaction below is:



- A. $K = \{[\text{NO}_2]^4 \times [\text{BaO}]^2 \times [\text{O}_2]\} / [\text{Ba}(\text{NO}_3)_2]^2$
B. $K = \{[\text{NO}_2]^4 \times [\text{O}_2]\}$
C. $K = [\text{Ba}(\text{NO}_3)_2]^2 / \{[\text{NO}_2]^4 \times [\text{BaO}]^2 \times [\text{O}_2]\}$
D. $K = 1 / \{[\text{NO}_2]^4 \times [\text{O}_2]\}$
E. $K = \{4 \times [\text{NO}_2] \times [\text{O}_2]\}$
29. Which one of the following aqueous solutions will have the lowest freezing point?
- A. 0.25 m AlBr₃
B. 0.25 m NaBr
C. 0.25 m C₁₂H₂₂O₁₁(sugar)
D. 0.25 m HF
E. 0.25 m CaBr₂
30. Consider the reaction below at equilibrium.



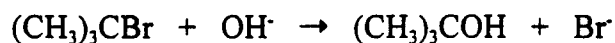
Which of the following stresses applied to a mixture of the three gases at equilibrium will cause the formation of more Cl₂?

- A. Increase the pressure by reducing the volume.
B. Add a catalyst.
C. Raise the temperature.
D. Remove half of the gaseous BrCl.
E. Add more gaseous Br₂.
31. Silver forms a soluble complex ion $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{-3}$ with $K_f = 2.9 \times 10^{13}$. The equilibrium concentration of Ag⁺ in a 0.20 M solution of $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{-3}$ is:
- $$\text{Ag}^+(\text{aq}) + 2 \text{S}_2\text{O}_3^{2-}(\text{aq}) \leftrightarrow [\text{Ag}(\text{S}_2\text{O}_3)_2]^{-3}(\text{aq}) \quad K_f = 2.9 \times 10^{13}$$
- A. $1.7 \times 10^{-15} \text{ M}$
B. $3.4 \times 10^{-14} \text{ M}$
C. $1.2 \times 10^{-5} \text{ M}$
D. $1.7 \times 10^{-13} \text{ M}$
E. 0.20 M
32. Geometric isomers are possible for which of the following:
(where M=central metal cation and X, Y designate different ligands)
- A. MX₂Y₂ (tetrahedral)
B. MX₃Y (square planar)
C. MX₂Y₂ (square planar)
D. MX₄Y₂ (octahedral)
E. Geometric isomers are possible for C and D.

33. Use crystal field theory to decide how many unpaired electrons in the metal 3d orbitals for the octahedral complexes below.

	$[\text{MnF}_6]^{3-}$	$[\text{Mn}(\text{CN})_6]^{3-}$
A.	four	two
B.	three	three
C.	five	one
D.	two	four
E.	two	two

34. Consider the reaction and rate law below

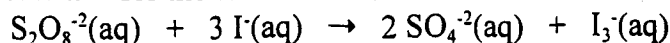


$$\text{Rate} = k[(\text{CH}_3)_3\text{CBr}]$$

Which of the following will NOT increase the rate of reaction?

- A. Increase the reaction temperature.
B. Add a positive catalyst for the forward reaction.
C. Increase the concentration of $(\text{CH}_3)_3\text{CBr}$.
D. Increase the concentration of OH^- .
E. All of the above.
35. $\text{Al}_2(\text{SO}_4)_3$ is dissolved in water such that the concentration of SO_4^{2-} is 0.20 M. What is the concentration of Al^{3+} ?
- A. 0.067 M
B. 0.13 M
C. 0.60 M
D. 0.30 M
E. 0.39 M
36. In the qualitative analysis scheme, initial separation of the metal cations into Groups I-V is based on _____.
- A. differences in acid/base properties of the metal cations.
B. amphoteric properties.
C. differences in K_{sp} values.
D. ability to form ammonia complexes.
E. hydrolysis of the metal cations.

37. Determine the rate law for the reaction below

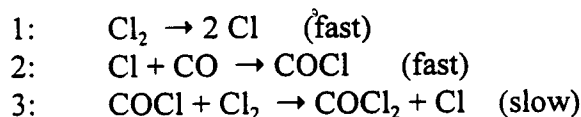


given the initial rate data

Exp #	$[\text{S}_2\text{O}_8^{2-}]$	$[\text{I}^-]$	Initial Rxn Rate (M/sec)
1	0.10	0.10	3.60×10^{-3}
2	0.20	0.10	7.20×10^{-3}
3	0.10	0.30	10.8×10^{-3}

- A. Rate = $k[\text{S}_2\text{O}_8^{2-}][\text{I}^-]^3$
- B. Rate = $k[\text{S}_2\text{O}_8^{2-}][\text{I}^-]^5$
- C. Rate = $k[\text{S}_2\text{O}_8^{2-}][\text{I}^-]^2$
- D. Rate = $k[\text{S}_2\text{O}_8^{2-}]^2[\text{I}^-]$
- E. Rate = $k[\text{S}_2\text{O}_8^{2-}][\text{I}^-]$

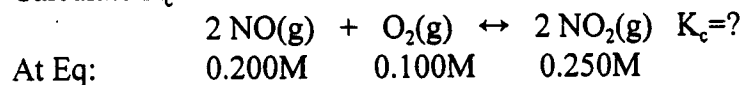
38. A three step mechanism has been suggested for formation of COCl_2 :



The intermediate is _____ and the molecularity of the rate determining step is _____.

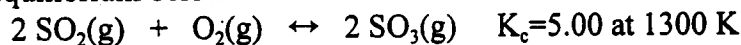
- A. COCl ; bimolecular
- B. CO ; unimolecular
- C. COCl_2 ; bimolecular
- D. Cl_2 ; bimolecular
- E. COCl ; unimolecular

39. Calculate K_c for the reaction below:



- A. 0.0800
- B. 0.0641
- C. 12.5
- D. 15.6
- E. 3.95

40. Consider the equilibrium below

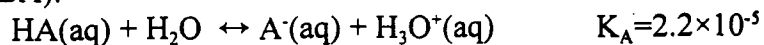


If the initial concentrations are: $[\text{SO}_2]_i = 1.20 \text{ M}$, $[\text{O}_2]_i = 0.45 \text{ M}$, and $[\text{SO}_3]_i = 2.10 \text{ M}$, the reaction will:

- A. be at equilibrium.
- B. shift to the left to reach equilibrium.
- C. shift to the right to reach equilibrium.
- D. not shift at all unless the temperature is increased.
- E. None of the above.

F6

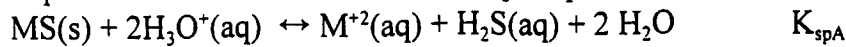
41. Para-aminobenzoic acid (PABA; a weak acid with $K_A=2.2\times 10^{-5}$) is used in some sunscreens and hair conditioning products. The acid equilibrium can be represented as below (HA represents PABA):



The pH of a 0.10 M solution of PABA is:

- A. 2.83
B. 5.69
C. 6.91
D. 11.17
E. 3.78
42. Which of the following is NOT a Lewis base?
- A. H_2O
B. NH_3
C. K^+
D. Cl^-
E. OH^-
43. Which of the following is a buffer?
- A. 0.5 M HCl/0.1 M NaCl
B. 0.5 M NaOH/0.1 M NaCl
C. 0.5 M NH_3 /0.1 M NaOH
D. 0.5 M HClO_2 /0.1 M NaClO_2
E. 0.5 M HClO_2 /0.5 M NaOH
44. 25.0 mL of 0.100 M HNO_3 is titrated with 0.150 M NaOH. What is the pH of the solution after the addition of 12.0 mL of NaOH?
- A. 0.15
B. 1.72
C. 2.51
D. 12.28
E. 7.00

45. A solution is 0.010 M in Mn^{2+} , Zn^{2+} , Pb^{2+} and Cu^{2+} and 0.010 M in H_2S at a $\text{pH}=0.50$. Calculate the ion product. Which metal cations will precipitate as the sulfide?

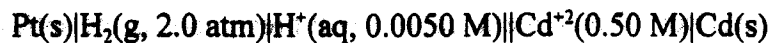


	K_{spA}
MnS	3×10^{16}
ZnS	3×10^{-2}
PbS	3×10^{-7}
CuS	6×10^{-16}

- A. Mn^{2+}
 B. Cu^{2+}
 C. Pb^{2+} and Cu^{2+}
 D. Zn^{2+} , Pb^{2+} and Cu^{2+}
 E. All will precipitate.
46. 10.0 mL of 0.20 M $\text{HC}_2\text{H}_3\text{O}_2$ is titrated with 0.15 M NaOH. The volume of base needed to reach the equivalence point is _____.
- A. 7.5 mL
 B. 13 mL
 C. 3.0 mL
 D. 10. mL
 E. 30. mL
47. Consider the titration in the last question. If the concentration of $\text{NaC}_2\text{H}_3\text{O}_2$ at the equivalence point is 0.086 M, the pH at the equivalence point is:
 ($K_{\text{A}}(\text{HC}_2\text{H}_3\text{O}_2)=1.8 \times 10^{-5}$)
- A. 6.90
 B. 10.03
 C. 5.26
 D. 9.63
 E. 8.84
48. A 1.138 g sample of naproxen (an anti-inflammatory agent) is dissolved in 0.0297 L of benzene solution. The osmotic pressure of the resulting solution is 4.00 atm at 20°C . The molar mass of naproxen is:
- A. 176 g/mol
 B. 307. g/mol
 C. 3.80×10^5 g/mol
 D. 230. g/mol
 E. None of the above.

F7

49. The standard net cell potential E°_{cell} is -0.40 V for the cell specified below.



The net cell potential E_{cell} under the nonstandard conditions specified above is:
(HINT: Write the net cell reaction first)

- A. -0.60 V
- B. $+0.36 \text{ V}$
- C. -0.26 V
- D. $+0.54 \text{ V}$
- E. -0.35 V

50. Mark the same answer as Question #49. This means that Question #49 is worth double.

Backtest from Summer II '1998

FINAL EXAM

Version I Key
(White)

- 1 D.
- 2 A.
- 3 C.
- 4 A.
- 5 C.
- 6 A.
- 7 C.
- 8 B.
- 9 B.
- 10 B.
- 11 D.
- 12 A.
- 13 A.
- 14 D.
- 15 B.
- 16 B.
- 17 A.
- 18 A.
- 19 D.
- 20 C.

- 21 E.
- 22 E.
- 23 D.
- 24 B.
- 25 D.
- 26 E.
- 27 D.
- 28 B.
- 29 A.
- 30 C.
- 31 C.
- 32 E.
- 33 A.
- 34 D.
- 35 B.
- 36 C.
- 37 E.
- 38 A.
- 39 D.
- 40 B.

- 41 A.
- 42 C.
- 43 D.
- 44 B.
- 45 C.
- 46 B.
- 47 E.
- 48 D.
- 49 C.
- 50 C.

A: ~~||||~~ ~~||||~~ | 11
 B: ~~||||~~ ~~||||~~ | ~~12~~ 11
 C: ~~||||~~ ~~||||~~ | 11
 D: ~~||||~~ ~~||||~~ | 11
 E: ~~||||~~ | 6

33
 + 6

 39
 + 12

 51