



CHEMISTRY 1210

Final Exam

April 17, 2014

Time: 3 hours

Name: _____

Student #: _____

Instructions:

Answer all questions on the exam paper.

Circle correct answers for multiple choice questions.

Show all work for non-multiple choice problems.

The left hand pages may be used for rough work; these pages will not be graded.

A formula sheet and periodic table are provided; no other materials may be used.

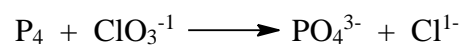
Work independently. Cheating will not be tolerated.

This exam should have 34 questions.

Unless otherwise specified you may assume the temperature is 25°C

Page	Mark	Maximum
2		5
3		6
4		5
5		5
6		6.5
7		4
8		5
9		7.5
10		7
11		6
12		7
13		6
14		8
15		6
16		5
Total		89

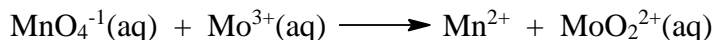
1) **[5 marks total]** The following oxidation-reduction reaction occurs in *basic* solution:



a) **[4 marks]** Balance the reaction.

b) **[1 mark]** Which species is the reducing agent? _____

- 2) **[3 marks total]** A 25.00-mL sample of a solution of Mo^{3+} solution was reacted with 0.0600 N KMnO_4 :

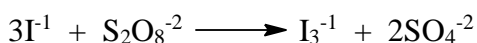


- a) **[1 mark]** If the Mo^{3+} in the reaction came from MoCl_3 (molar mass 202.3 grams), what is the equivalent mass of the MoCl_3 ?
- b) **[2 marks]** The 25.00 mL sample of Mo^{3+} solution required 15.00 mL of the KMnO_4 solution for complete reaction. Determine the *molarity* of the Mo^{3+} in the solution.
- 3) **[1 mark]** The activation energy for the forward direction of a reaction is 50 kJ and for the reverse direction is 30 kJ. The ΔH for the overall reaction is:
- a) -20 kJ
 - b) 20 kJ
 - c) -80 kJ
 - d) 80 kJ
 - e) There is not enough information to answer this question.
- 4) **[2 marks]** The uncoiling of DNA is a first order process with an activation energy of about 420 kJ/mol. At 50°C the half-life for uncoiling is estimated to be 2 minutes. What is the half-life at a normal body temperature of 37°C?
- a) 2.8×10^{-3} min
 - b) 1.4 min
 - c) 2 min
 - d) 2.85 min
 - e) 1411 min

5) [2 marks] A reaction has a rate constant $k = 1.25 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$. If the initial concentration of the reactant is 0.0750 M, what concentration remains after 10.0 minutes?

- a) 0 M
- b) 0.0696 M
- c) 0.0738 M
- d) 0.0749 M
- e) 0.150 M

6) [3 marks] The rate of the reaction:



was studied using the iodine clock technique and the following data were obtained (t is the time the reaction took):

Run	$[\text{I}^{-1}]_0$ (M)	$[\text{S}_2\text{O}_8^{2-}]_0$ (M)	t (s)
1	0.0400	0.0400	88.0
2	0.0800	0.0400	44.0
3	0.0800	0.0800	22.1

a) The order of this reaction with respect to $\text{S}_2\text{O}_8^{2-}$ is:

- i) 0
- ii) $\frac{1}{2}$
- iii) 1
- iv) 2
- v) 3

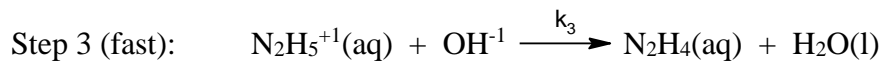
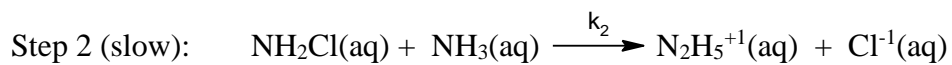
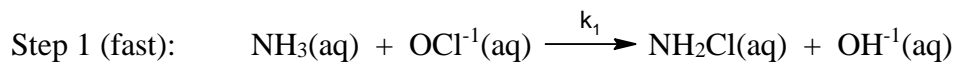
b) The overall order of this reaction is:

- i) 0
- ii) $\frac{1}{2}$
- iii) 1
- iv) 2
- v) 3

c) If a run is made with $[\text{I}^{-1}]_0 = 0.120 \text{ M}$ and $[\text{S}_2\text{O}_8^{2-}]_0 = 0.0400$, you would expect the reaction to complete in approximately:

- i) 29 s
- ii) 33 s
- iii) 44 s
- iv) 66 s
- v) 88 s

- 7) **[5 marks total]** The Raschig reaction produces aqueous hydrazine, $\text{N}_2\text{H}_4(\text{aq})$, from $\text{NH}_3(\text{aq})$ and $\text{OCl}^{-1}(\text{aq})$ in basic, aqueous solution. A proposed mechanism is:



- a) **[3 marks]** Determine the rate law based on this reaction mechanism, show all your work clearly.

b) **[1 mark]** The following substances are intermediates: _____

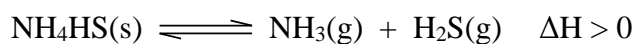
c) **[1 mark]** This reaction mechanism involves a catalyst (circle one): YES NO

8) [2 marks] Find K_p for the following reaction at 25°C:



- a) 3.9×10^{-10}
- b) 5.6×10^{-8}
- c) 3.9×10^{-6}
- d) 5.6×10^{-4}
- e) 1.5
- f) 100

9) [2.5 marks total] For the equilibrium mixture at 200°C:

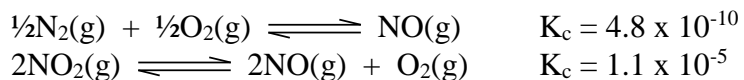


Indicate if the partial pressure of NH_3 will increase, decrease or remain the same when the following changes are made:

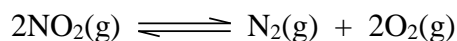
(Circle your choice: I – increase D – decrease NC – no change)

Add some Ne	I	D	NC
Add some H_2S	I	D	NC
Add some NH_4HS	I	D	NC
Increase the temperature	I	D	NC
Double the volume of the container (at constant T)	I	D	NC

10) [2 marks] Given the following equilibria:



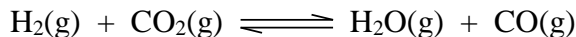
K_c for the equilibrium:



will be:

- a) 2.5×10^{-24}
- b) 5.3×10^{-15}
- c) 2.1×10^{-14}
- d) 2.3×10^4
- e) 4.8×10^{13}

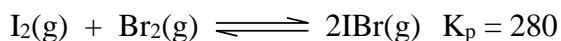
11) [2 marks] At a given temperature, $K_c = 3.24$ for the reaction:



If 0.800 mol of both H_2 and CO_2 are placed in a 1.00 L container at this temperature, when the system comes to equilibrium the concentration of $\text{CO}(\text{g})$ will be:

- a) 1.60 M
- b) 0.800 M
- c) 0.611 M
- d) 0.514 M
- e) 0.247 M

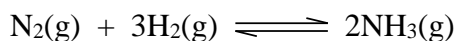
12) [1 mark] For the reaction:



If a container is filled with these gases, such that $P(\text{I}_2) = 10.0$ bar, $P(\text{Br}_2) = 5.0$ bar, and $P(\text{IBr}) = 20.0$ bar, in which direction will the reaction proceed?

- a) The reaction proceeds to the left.
- b) The reaction proceeds to the right.
- c) The reaction is at equilibrium.
- d) The reaction volume is required in order to answer this question.
- e) The temperature is required in order to answer this question.

13) [1 mark] Choose the correct statement when the reaction



is at equilibrium:

- a) The rate constant for the forward reaction is equal to the rate constant for the reverse reaction.
- b) The rate for the forward reaction is equal to the rate for the reverse reaction.
- c) The concentrations of all reactants and products are equal.
- d) Increasing the volume of the reaction container will increase the yield of ammonia.
- e) The equilibrium expression for the reaction is $K_c = \frac{[\text{N}_2][\text{H}_2]^3}{[\text{NH}_3]^2}$

14) [2 marks] An indicator ($pK_a = 5.0$) changes colour from yellow to blue. It last appears yellow when $[\text{Ind}^{1-}]/[\text{HInd}] = 0.04$ and appears completely blue when $[\text{Ind}^{1-}]/[\text{HInd}] = 4$.

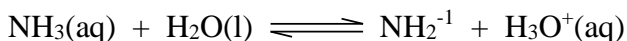
- a) Calculate the pH range over which this indicator changes colour and place those pH values in the appropriate blanks below.

pH range: _____(yellow) to _____(blue)

- b) Would this be a suitable indicator to use for the titration of NH_3 with HCl ?
(Circle your choice.)

Yes No

15) [1 mark] In the equilibrium system



Bronsted-Lowry theory would designate:

- a) NH_3 and H_2O as the bases.
- b) H_2O and OH^{1-} as a conjugate pair.
- c) NH_2^{1-} and H_3O^+ as the acids.
- d) NH_2^{1-} and H_2O as a conjugate pair.
- e) NH_3 as amphiprotic.

16) [2 marks] A 10.0 mL sample of a 0.125 M solution of an unknown monoprotic acid has a $\text{pH} = 2.95$. What is its ionization constant, K_a ?

- a) 1.0×10^{-7}
- b) 1.3×10^{-6}
- c) 1.0×10^{-5}
- d) 1.1×10^{-3}
- e) 9.8×10^{-3}

17) **[3 marks]** Methylamine, CH_3NH_2 , has a $K_b = 3.2 \times 10^{-5}$. What is its percent ionization in 1.0 and 0.1 M solutions, respectively?

- a) 0.018% and 0.056%
- b) 0.032% and 0.0032%
- c) 0.56% and 1.8%
- d) 0.56% in both
- e) 0.32% in both

18) **[2.5 marks]** Match the descriptions given below with one of the mixtures described in questions (a) – (e):

I – A solution with a pH less than 7 that is not a buffer

II – A buffer solution with a pH between 4 and 7

III – A solution with a pH of 7

IV – A buffer solution with a pH between 7 and 10

V – A solution with a pH greater than 7 that is not a buffer

- a) A mixture of 1 mole NaOH and 1 mole NaCl in enough water to make 1.0 L _____
- b) A mixture of 1 mole NaCl and 1 mole CaCl_2 in enough water to make 1.0 L _____
- c) A mixture of 1 mole NaF and 0.5 mole HF in enough water to make 1.0 L _____
- d) A mixture of 50.0 mL 0.10 M HCl with 25.0 mL 0.10 M NH_3 _____
- e) A mixture of 25.0 mL 0.10 M HCl with 50.0 mL 0.10 M NH_3 _____

19) **[2 marks]** What mass of sodium acetate (molar mass 82 g) should be dissolved in 200.0 mL of 0.20 M acetic acid to form a buffer of pH = 5.0? K_a for acetic acid is 1.8×10^{-5} .

20) **[3 marks]** What is the pH at the equivalence point for the titration of 0.10 M benzoic acid by 0.10 M sodium hydroxide? (K_a for benzoic acid is 6.3×10^{-5})

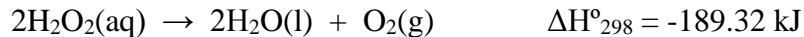
21) **[2 marks]** How many moles of SrF_2 will dissolve in 1 L of 0.10 M $\text{Sr}(\text{NO}_3)_2$ if K_{sp} for SrF_2 is 7.9×10^{-10} ?

- a) 2.8×10^{-5}
- b) 4.4×10^{-5}
- c) 7.9×10^{-8}
- d) 4.0×10^{-9}
- e) 7.9×10^{-9}

22) **[2 marks]** A solution is 0.120 M in Pb^{2+} . If the K_{sp} for $\text{PbCrO}_4 = 1.8 \times 10^{-14}$. In order to precipitate 99.9% of all the Pb^{2+} present, the $[\text{CrO}_4^{2-}]$ must be:

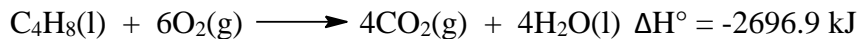
- a) 1.8×10^{-17}
- b) 1.8×10^{-14}
- c) 1.5×10^{-13}
- d) 1.5×10^{-10}
- e) 1.3×10^{-7}

23) [6 marks total] Given the reaction:



- a) [2 marks] Estimate the bond dissociation energy for the O-O single bond. The bond energy for the O₂ molecule is 498.3 kJ/mol, and the enthalpies of vaporization of H₂O₂(aq) and H₂O(l) are approximately equal.
- b) [1 mark] Give two reasons why your answer above is an estimate and not an accurate calculation of the bond dissociation energy.
- c) [3 marks] One litre of a solution initially 0.0100 M in H₂O₂ and at 25.000°C is reacted. If all the heat produced in the reaction is retained in the solution, what would be the final temperature? Assume the specific heat capacity of the solution to be 4.184 J g⁻¹K⁻¹, and that the density of the solution is 1.00 g/mL.

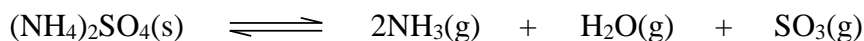
24) [2 marks] Given the reaction:



and that the molar enthalpies of formation of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -393.5 kJ and -285.8 kJ respectively, the molar enthalpy of formation of butane ($\text{C}_4\text{H}_8(\text{l})$) is:

- a) $+2017 \text{ kJ/mol}$
- b) -20.3 kJ/mol
- c) -107.6 kJ/mol
- d) -2017 kJ/mol
- e) $+20.3 \text{ kJ/mol}$

25) [8 marks total] For the following system:



$$\Delta\text{H}^\circ_{298} = +449.6 \text{ kJ}$$

$$\Delta\text{S}^\circ_{298} = +609.62 \text{ J/mol K}$$

a) $\Delta\text{G}^\circ_{298} = 267.9 \text{ kJ}$

i) [2 marks] $K_{p,298}$ for this reaction is:

- (1) 1.0×10^{-4696}
- (2) 1.1×10^{-47}
- (3) 2.0×10^{-5}
- (4) 0.90
- (5) 9.1×10^{46}

ii) [2 marks] Determine the value of ΔG_{298} when $P(\text{NH}_3) = 0.0010 \text{ bar}$, $P(\text{H}_2\text{O}) = 0.0020 \text{ bar}$ and $P(\text{SO}_3) = 0.0020 \text{ bar}$.

iii) [1 mark] Under the conditions in part (c) the forward reaction is: (circle one)

spontaneous

non-spontaneous

b) [1 mark] At what temperature will this reaction be at equilibrium under standard conditions?

c) [2 marks] $K_{p,1000}$ for this reaction will be:

- i) 4.4×10^{-9}
- ii) 1.0×10^{-14}
- iii) 2.3×10^8
- iv) 9.9×10^{13}
- v) 8.8×10^{835}

26) [3 marks total] A concentration cell uses a standard hydrogen electrode (SHE) for one half cell. The other half-cell also uses $H_2(g)$ at 1 bar pressure, but the hydrogen ions in solution come from a weak acid. The cell so constructed produces 0.245 V.

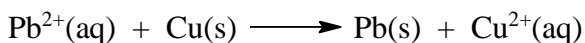
a) [0.5 marks] The SHE is the (circle one): ANODE CATHODE

b) [0.5 marks] The process occurring at the SHE is (circle one):

OXIDATION REDUCTION

c) [2 marks] Determine the pH of the buffered solution.

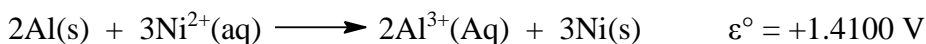
27) [2 marks] Determine the equilibrium constant (K_c) for the following reaction at 25°C.



Given the standard reduction potentials: $\text{Pb}^{2+}/\text{Pb} = -0.125 \text{ V}$ and $\text{Cu}^{2+}/\text{Cu} = +0.337 \text{ V}$

- a) 2.41×10^{-16}
- b) 6.80×10^{-8}
- c) 1.65×10^{-7}
- d) 1.46×10^7
- e) 4.15×10^{15}

28) [2 marks] Given the reaction:



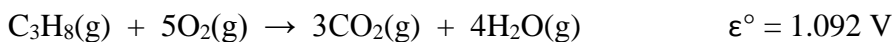
What would be the voltage if $[\text{Ni}^{2+}] = 0.020 \text{ M}$ and $[\text{Al}^{3+}] = 3.60 \text{ M}$?

- a) 1.3880 V
- b) 1.4322 V
- c) 1.4712 V
- d) 1.3488 V
- e) 1.3182 V

29) [2 marks] A copper electrode weighs 35.42 g before electrolysis (of a CuSO_4 solution) and 36.69 g after. The electrolysis was performed using a current of 3.50 amperes. How long did the electrolysis take?

- a) 9.2 s
- b) 275 s
- c) 551 s
- d) 1102 s
- e) $1.35 \times 10^4 \text{ s}$

30) [2 marks] Given the reaction:



What is ΔG° ?

- a) -2108 kJ
- b) -211 kJ
- c) -105 kJ
- d) 211 kJ
- e) 2108 kJ

- 31) **[1 mark]** The normal boiling point of a liquid:
- a) Is the temperature at which the liquid and vapour are in equilibrium
 - b) Varies with the atmospheric pressure
 - c) Is the temperature at which the vapour pressure of the liquid is 1 atm
 - d) Is the temperature at which the vapour pressure of the liquid equals the external pressure
 - e) Is directly proportional to the molar mass of the liquid.
- 32) **[2 marks]** At 35°C, the vapour pressure of CS₂ is 512 mmHg, and of acetone, CH₃COCH₃, is 344 mmHg. It is known that the acetone-CS₂ intermolecular forces are weaker than the acetone-acetone or CS₂-CS₂ intermolecular forces. Given this information, you would expect that:
- a) A mixture of 100.0 mL of acetone and 100.0 mL of CS₂ has a volume of 200.0 mL.
 - b) A mixture of 100.0 mL of acetone and 100.0 mL of CS₂ has a volume less than 200.0 mL.
 - c) When acetone and CS₂ are mixed at 35°C heat is absorbed.
 - d) When acetone and CS₂ are mixed at 35°C heat is evolved.
 - e) The vapour pressure above the solution would be lower than predicted.
- 33) **[3 marks]** The primary constituent of lemon oil is the hydrocarbon, limonene, that is 88.16% C and 11.84% H. A solution of 8.362 g of limonene in 50.00 g of benzene freezes at 2.37°C. Pure benzene freezes at 5.5°C. The freezing point depression constant for benzene is 5.12°C kg/mol. Determine the molecular formula of limonene.

- 34) **[5 marks total]** A certain compound has a normal melting point of 41°C and a normal boiling point of 123°C . The triple point is at 39°C and 85 mmHg .
- a) **[3 marks]** Sketch the phase diagram for this substance. Label all regions, lines and points appropriately.
- b) **[1 mark]** Does the solid phase of this substance have a density greater or less than that of the liquid phase? How do you know? (No marks for guessing. ☺)
- c) **[1 mark]** Describe what happens when a sample of this substance at 2 atm and a temperature of 20°C is heated at constant pressure to a temperature of 50°C .