

Chemistry 2

First Lecture Exam

Spring 2012

Name _____

Circle the name of your recitation instructor

Eisenberg Kahanda Kelebeyev Levine Mathias

Before you begin the exam, write your name on this page.The exam is printed on **both sides** of the paper. If you need more space use page 2 or the last page.For questions 12-26, show all work. Express answers with the proper units .

You have 90 minutes. Do not spend too much time on one question.

This exam has 5 sheets and 9 pages. Make sure you have all of them.**Use of cell phones or graphing calculators or iPads is forbidden.**

PERIODIC CHART OF THE ELEMENTS

IA	IIA												IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0079																	1 H 1.0079	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179	
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948	
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.905	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29	
55 Cs 132.91	56 Ba 137.33	57 *La 138.90	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra 226.0	89 #Ac 227.03																

* Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
# Actinides	90 Th 232.03	91 Pa 231.03	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (257)	102 No (255)	103 Lr (256)

PAGE 2 IS BLANK

Name _____

1. (9 pts) State whether each of the following is True or False. (Write True or False; NOT T or F).

(a) The rate law for the **elementary** reaction $A + 2B \rightarrow \text{products}$ must be: $\text{rate} = k[A][B]^2$.

(b) For the weak diprotic acid $\text{H}_2\text{SO}_3(\text{aq})$, it is a good approximation to ignore the second ionization step when finding the pH of this aqueous solution.

(c) The value of the rate constant k of a reaction changes when the concentrations of the reactants change.

(d) When the reaction $B \rightleftharpoons C$ has reached equilibrium, the number of moles of B present must equal the number of moles of C present.

(e) A molecule that is a Lewis base must have at least one pair of unshared electrons.

(f) For a conjugate acid–base pair, the larger the value of K_a is, the smaller the value of K_b is.

2. (3 pts) The ion $\text{HCO}_3^- (\text{aq})$ can act as an acid or a base **in water**.

(a) Write the reaction for it acting as a base.

(b) Write the reaction for it acting as an acid.

3. (3 pts) Classify each of these solutions as acidic, basic, or neutral.

(a) $\text{NaNO}_2(\text{aq})$ (b) $\text{Cr}(\text{NO}_3)_2(\text{aq})$

4. (2 pts) When using K_p , all pressures must be in units of _____.

When using K_c all concentrations must be in units of _____.

5. (2 pts) Which one of these ions has the smallest tendency to accept a proton?

(a) Br^- (b) OH^- (c) CN^-

6. (2 pts) For most homogeneous reactions, as time increases, the rate of reaction will

(a) increase (b) stay constant (c) decrease

EXAM continued on the BACK of this sheet

7. (6 pts) In a certain system, the following reaction is in equilibrium: $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$ Some $\text{NO}_2(\text{g})$ is added to this equilibrium system while keeping the temperature and volume constant. Answer questions (a) and (b) for the instant after the $\text{NO}_2(\text{g})$ is added but **before** the equilibrium shifts.
- (a) Does the addition of the $\text{NO}_2(\text{g})$ cause the equilibrium constant K_c for the reaction to increase, to decrease, or to remain the same?
- (b) Does the addition of the $\text{NO}_2(\text{g})$ cause the reaction quotient Q_c for the reaction to increase, to decrease, or to remain the same?
- (c) Does the addition of the $\text{NO}_2(\text{g})$ cause the equilibrium to shift to the right, to the left, or cause no shift?
8. (2 pts) Find the hydrogen ion concentration in a solution with $\text{pH} = 12.45$.
9. (2 pts) Write the equilibrium chemical reaction that occurs in an aqueous solution of the weak base $\text{C}_6\text{H}_5\text{NH}_2$.
10. (3 pts) Find the pH of a solution prepared by dissolving 7.29 g of HCl in water and diluting the solution to 100.0 mL.
11. (3 pts) K_w for water is greater at 40°C than it is at 25°C . (See the Note on the next page.)
- (a) At 40°C , the pH of pure water will be
- (i) less than 7.00 (ii) equal to 7.00 (iii) greater than 7.00
- (b) At 40°C , the H_3O^+ concentration in pure water will be
- (i) less than the OH^- concentration (ii) equal to the OH^- concentration (iii) greater than the OH^- concentration

Note: Assume the water is absolutely pure with no dissolved CO₂.

For Questions 12-26 . Show all work.

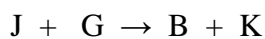
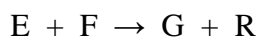
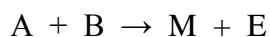
You are NOT allowed to use the Henderson-Hasselbalch equation

12. (3 pts) Find $[H^+]$ in 0.0600 M Ba(OH)₂(aq) at 25°C.
- 13 (5 pts) The reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ has $K_c = 50.5$ at 448°C. A 1.00 L container at 448°C has 0.20 mol of H₂, 0.10 mol of I₂, and 0.80 mol of HI. (a) Is this system in equilibrium? (b) If it is not in equilibrium, will the reaction go to the right or to the left to reach equilibrium? You MUST show calculations to back up your answers. (c) At equilibrium will the amount of HI be less than, equal to, or greater than 0.80 moles?
14. (3 pts) The activation energy for the reaction $A + B \rightarrow C + D$ is 110 kJ/mol and the activation energy of the reverse reaction is 150 kJ/mol. Find ΔE for this reaction. (A diagram might help you.)
15. (4 pts) The reaction $D + N \rightarrow \text{products}$ is *second* order in D and is *first* order in N. At 25°C, when the initial D concentration is 0.40 M and the initial N concentration is 0.70 M, the initial rate of this reaction is $5.0 \times 10^{-4} \text{ M s}^{-1}$. Find the rate constant for this reaction at 25°C. **Exam continued on the back.**

16. (3 pts) At 400°C, the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) = 2\text{NH}_3(\text{g})$ has $K_P = 4.2$. In a certain system that is **at equilibrium** at 400°C, the H_2 partial pressure is 0.40 atm and the NH_3 partial pressure is 0.15 atm. Find the N_2 partial pressure in this equilibrium system.

17. (1 pt) If $\log x = -1200.340$, find x . Express your answer in scientific notation. Zero is not an acceptable answer.

18. (7 pts) A certain reaction has the following three-step mechanism:



(a) Write the overall reaction.

(b) State whether **each** of these species is a reactant, a product, an intermediate, or a catalyst:

B M G F

(c) Is the second step in this mechanism unimolecular, bimolecular, or termolecular (trimolecular)?

19. (4 pts) Consider the reaction $\text{SrCO}_3(\text{s}) \rightleftharpoons \text{SrO}(\text{s}) + \text{CO}_2(\text{g})$

(a) Write the expression for the equilibrium constant K_P for this reaction.

(b) Suppose we remove some (but not all) $\text{SrCO}_3(\text{s})$ from a system where this reaction is in equilibrium, while keeping T constant. State whether the equilibrium shifts to the right, to the left, or does not shift.

20. (7 pts) Find $[H^+]$ in 0.40 M $NH_4NO_3(aq)$ at $25^\circ C$ given that $K_b = 1.8 \times 10^{-5}$ for $NH_3(aq)$ at $25^\circ C$.

You MUST begin by writing the chemical reaction that is at equilibrium.

21. (6 pts) Several experiments for the reaction $2A + B + 2C \rightarrow$ products gave these results

Experiment	Initial [A]	Initial [B]	Initial [C]	Initial rate
1	0.20 M	0.40 M	0.10 M	0.80 M/s
2	0.20 M	0.40 M	0.40 M	3.2 M/s
3	0.50 M	0.40 M	0.10 M	0.80 M/s
4	0.20 M	1.20 M	0.40 M	28.8 M/s

Find the order with respect to A. Find the order with respect to B. Find the order with respect to C.

When you find **each** order, you **must** state which **two** experiments you are using to find that order.

You do NOT have to give reasons for your answers. (Do **not** find the rate constant.)

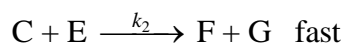
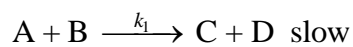
22. (2 pts) The reaction $A + 2B + C \rightarrow$ products is third order in A, is first order in B, and is zero order in C. If we double the initial A concentration and multiply the initial B concentration by 3 and double the initial C concentration, the rate will be multiplied by what factor? Show work.

Exam continued on the **back** of this page.

23. (4 pts) 5.00 moles of N_2 and 8.00 moles of H_2 are placed in an empty container, the container is heated to 887°C , and a catalyst is added that catalyzes the reaction of these gases to form NH_3 as the only product. At equilibrium, 1.00 mole of NH_3 is found to be present. Find the number of moles of N_2 and find the number of moles of H_2 that are present at equilibrium. (*Hint:* The value of the equilibrium constant is not given in this problem and it is not needed.)

24. (6 pts) Find $[\text{H}^+]$ in an aqueous solution that is 0.50 M in NaNO_2 and is 1.40 M in HNO_2 . For $\text{HNO}_2(\text{aq})$, $K_a = 4.5 \times 10^{-4}$.

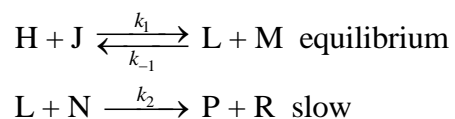
25. (6 pts) (a) A certain reaction has the mechanism



where the rate constant is written above each arrow. What is the rate law for this reaction? Your answer should have k_1 or k_2 or both in the rate equation.

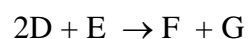
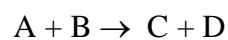
(b) See the next page

(b) A certain reaction has the mechanism



Find the rate law for this reaction. *Hint:* The rate law must not contain a reaction intermediate.

26. (2 pts) A reaction has the mechanism



Find the overall reaction. *Hint:* Think about the intermediate.

Reminder: Any work you did using the Henderson-Hasselbalch equation will earn you no credit.

Extra credit

EC1 (1.5 pts) Given that x must be positive, solve this equation for x :

$$0.12 = \frac{x^2}{0.45 - x}$$