Exam Two **CHM 205 (Dr. Mattson)** **18 February 2009**	***Academic Integrity Pledge:*** *In keeping with Creighton University's ideals and with the Academic Integrity Code adopted by the College of Arts and Sciences, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.* **Signature:**

Instructions: Show all work whenever a calculation is required! You will receive credit for how you worked each problem as well as for the correct answer. This exam is worth 100 points. BOX YOUR ANSWERS!

0. Do you want to receive grade reports via e-mail this semester? **Circle: Yes or No**

1. Consider the mechanism:

Step 1. A + B → C

Step 2. C + A → D

(a) (3 pts) What is the overall reaction?

(b) (3 pts) If the first step is the rate-determining step, what is the rate law?

(c) (2 pts) Is there an intermediate? If so, identify.

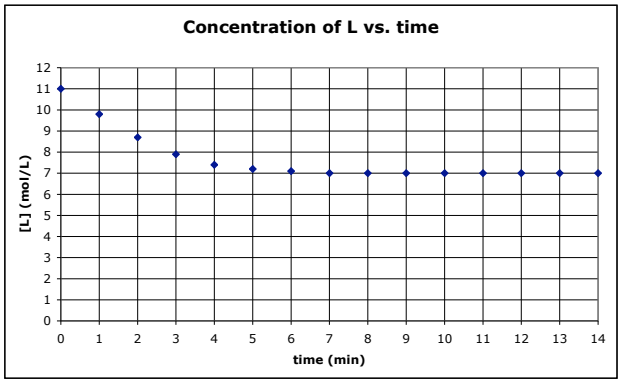
☐ No ☐ Yes, it is A B C D

(d) (2 pts) Is there a catalyst? If so, identify.

☐ No ☐ Yes, it is A B C D

2. The following graph is for the reaction 2 L → R. The data plotted are for [L] vs. time.

(a) (4 pts) Accurately, sketch in the line for [R] vs. time.



(b) (5 pts) What is the equilibrium expression, K_c and what is its numerical value?

(c) (2 pts) What would happen to the value of K_c if some R were added?

No change to K_c K_c increases K_c decreases

(d) (2 pts) What would happen to [L] if some R were added after 10 min and as equilibrium is restored?

No change to [L] [L] increases [L] decreases

3. Consider the reaction 2 A(g) $\rightleftharpoons$ B(g) + C(g), for which $K_c = 9.40$. The initial concentration of A is 0.70 M and [B] = [C] = 0 M.

(a) (5 pts) What are the equilibrium concentrations of all three gases?

(b) (2 pts) Once the reaction comes to equilibrium, what would happen if the volume of the container were decreased? Circle your choice in the sentence:

The reaction would [*shift left* *shift right* *not shift*] in order to reestablish equilibrium.

4. The reaction E → F is endothermic and proceeds by a single step mechanism.

(a) (3 pts) Sketch a reaction profile here.

(b) (4 pts) On the graph above, label E_{act}^{fwd} and E_{act}^{rev}.

(c) (3 pts) On the above sketch how things would be different if a catalyst were added.

(d) (2 pts) How does ΔE relate to E_{act}^{fwd} and E_{act}^{rev}? Circle:

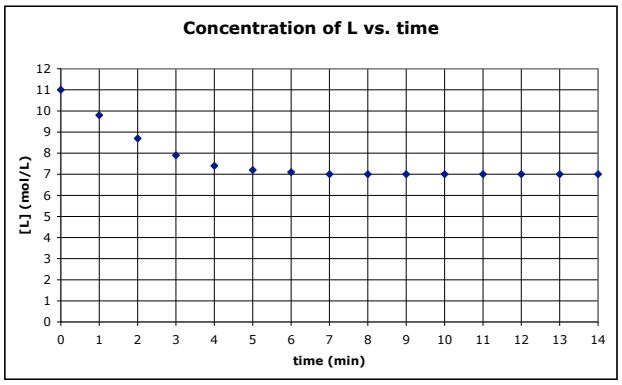
(A) $\Delta E = E_{act}^{rev} - E_{act}^{fwd}$ (B) $\Delta E = E_{act}^{fwd} + E_{act}^{rev}$

(C) $\Delta E = E_{act}^{fwd} - E_{act}^{rev}$ (D) $\Delta E = E_{act}^{fwd} / E_{act}^{rev}$

(e) (2 pts) How does K_c compare to K_p for this reaction?

(A) $K_c = K_p$ (B) $K_c = K_pRT$ (C) $K_p = K_cRT$

5(a) (4 pts) Revisiting the reaction in Question 3, 2 L → R, suppose that the forward reaction is exothermic. How would the data for [L], plotted below, change if the temperature were raised? Answer the question by sketching your predicted [L] on the graph. Hint: There are <u>two</u> things you should consider.



(b) (2 pts) Add a line for the new [R].

6. (4 pts) At equilibrium, the concentrations of H_2 and N_2 are 0.23 M and 0.35 M, respectively. What is the equilibrium concentration of NH_3?

$$3\ H_2 + N_2 \rightleftharpoons 2\ NH_3 \quad K_c = 4.19$$

7. (6 pts) Which of these are strong acids in aqueous solution? Circle all that are.

(A) HNO_2 (B) HNO_3 (C) H_2SO_3

(D) H_2SO_4 (E) HCl (F) HF

8(a) (2 pts) Write the reaction that shows the dissociation of HCl in aqueous solution.

(b) (4 pts) What is the pH of a 2.7×10^{-4} M HCl solution?

9(a) (2 pts) Write the equilibrium that shows the dissociation of $HC_3H_5O_2$ in aqueous solution.

(b) (5 pts) What is the pH of a 0.75 M $HC_3H_5O_2$ solution given that $K_a = 5.2 \times 10^{-5}$?

10. (9 pts) Complete the table.

Acid	**K_a**	**pK_a**	**Conjugate Base**	**K_b**
HA	1×10^{-3}			
HB	1×10^{-6}			
HC	1×10^{-9}			

11. (5 pts) Suppose 0.84 g benzoic acid, $HC_7H_5O_2$ (MM = 122 g/mol) were dissolved in water to make 250.00 mL solution. The resulting solution had a pH of 4.32. What is the K_a of the solution?

12. (6 pts) Analine is a weak base. What is the pH of a 0.78 M analine solution? [K_b value of 4.3×10^{-10}]

13. (6 pts) What is the pH of a 0.25 M sodium acetate solution, given that the pK_a for acetic acid is 4.74?

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Answers

1. (a) 2 A + B → D; (b) rate = k[A][B]; (c) Yes, C; (d) No

2. The following graph is for the reaction 2 L → R. The data plotted are for [L] vs. time.

(a) R drops from 11.0 mol/L to 7.0 mol/L or by 4.0 mol/L. Since the stoichiometry is 2L → R, R should go up from 0 mol/L to 2.0 mol/L (half of what L goes down. The kinetics part should take 5 minutes as it does to L.

(b) $K_c = [R]/[L]^2 = 2.0/7.0^2 = 0.0408$; (c) No change to K_c; (d) [L] increases

3. (a) [A] = 0.098 M, [B] = [C] = 0.301 M; (b) not shift

4. (a) Drawing should have one hump and the right side should be higher in energy than the left side.

(b) E_{act}^{fwd} is the energy from the left side to the top of the hill and and E_{act}^{rev} is the energy from the right side to the top of the hill.

(c) Drawing should start and end where it did in (a), however, it should follow a lower energy pathway and usually adds one more step (so one big hill becomes two smaller hills)

(d) C; (e) (A)

5(a) If the forward reaction is exothermic, the reverse reaction is endothermic and increasing the temperature always favors the endothermic direction. Therefore, there should be more L at equilibrium than in the drawing. Also, increasing the temperature speeds up all reactions, so equilibrium is attained more quickly. I looked for (a) a shorter kinetics region and (b) the new equilibrium concentration of L being higher than before.

(b) This like should have the new, shorter kinetics region, it should start at o and should go up half as much as L goes down in the drawing.

6. 0.133 mol/L

7. B, D, E

8(a) $HCl + H_2O \rightarrow H_3O^+ + Cl^-$; (b) 3.57

9(a) $HC_3H_5O_2 + H_2O \xleftarrow{\rightarrow} H_3O^+ + C_3H_5O_2^-$; (b) 2.20

10.

Acid	K_a	pK_a	Conjugate Base	K_b
HA	1×10^{-3}	3	A^-	1×10^{-11}
HB	1×10^{-6}	6	B^-	1×10^{-8}
HC	1×10^{-9}	9	C^-	1×10^{-5}

11. 8.31×10^{-8}

12. 9.26

13. 9.23