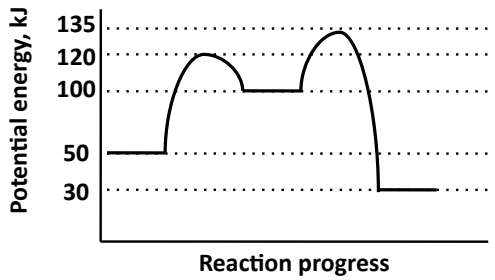
Exam 2 Chm 205 (Dr Mattson) 26 February 2013

Academic Integrity Pledge: *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.*

(1 pt) Signature:

Instructions: Show all work whenever a calculation box is provided! Write legibly. Include units whenever appropriate. BOX YOUR ANSWERS! You will receive credit for how you worked each problem as well as for the correct answer. If you need more space, you may use the back of your data sheet — Write: "See data sheet" in the answer box and then hand the data sheet in with your exam. At your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks and purses must be stored in the front of the room. Cell phones must be OFF and placed at the front of the room.

Questions 1. (1 pt ea) Questions 1a – 1i refer to the following reaction profile diagram. Answer Questions 1c – 1f with numerical values calculated from the energies given for each of the dashed lines. Be careful: signs (+/-) matter!



1a. How many steps are there in this mechanism? Label the diagram.

1b. Which step is the slow step?

1c. What is the value of ΔH for the overall forward reaction? Units!

1d. What is the value of E_a^{fwd} for first step of the mechanism? Units!

1e. What is the value of E_a^{fwd} for second step of the mechanism? Units!

1f. What is the value of E_a^{rev} for second step of the mechanism? Units!

1g. From the intermediate, will a greater fraction of molecules (in terms of energy) go through Step 1(rev) or Step 2(fwd)?

Step 1(rev)

Step 2(fwd)

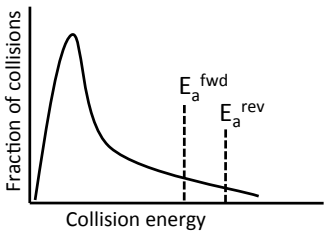
1h. Was a catalyst used?

Yes No

Can't tell

1i. Is the diagram shown at right consistent with Step 1 of the mechanism?

Yes No

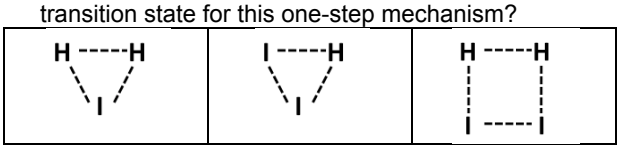


Questions 2a-e refers to the reaction:

$H_2(g) + I_2(g) \rightarrow 2\ HI(g)$ ΔH_{rxn} -362 kJ

2a. (2 pts) The mechanism for this reaction is elementary. What is the rate law?

2b. (2 pts) Which of these diagrams would be a reasonable transition state for this one-step mechanism?



2c – 2e. To answer Questions 2c – 2e, suppose instead the mechanism involved the following three steps.

Step 1. $I_2 \rightarrow 2\ I$

Step 2. $H_2 + I \rightarrow HI + H$

Step 3. $H + I \rightarrow HI$

2c. (2 pts) What is the rate law if the first step is slowest?

2d. (1 pt) Is there a catalyst? If so, identify it.

Yes No

2e. (1 pt) Is/are there intermediate(s)? If so, identify.

Yes No

Questions 3a-f refer to the equilibrium:

$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$ $K_c^{298} = 710$ $\Delta H = -362$ kJ

3a. (3 pts) Write the equilibrium expression, K_c.

3b. (5 pts) Suppose 0.0446 mol HI(g) were placed in a 1.0 L vessel and allowed to come to equilibrium at 298 K. What is the equilibrium concentration of each gas?

3c. (4 pts) In another experiment with the same reaction, suppose at some point it was determined that the concentrations of the three gases were: $[H_2]$ = 0.0205 M, $[I_2]$ = 0.0310 M, and [HI] = 0.0744 M. Is the system at equilibrium? If not, in which direction must it shift in order to attain equilibrium? Show all work for credit.

At equilibrium? Yes No Shift: R L No shift

3d. (4 pts) Suppose some $H_2(g)$ and $I_2(g)$ were placed in a 5.0 L vessel and allowed to come to equilibrium. If $[H_2]$ = 0.0118 M and $[I_2]$ = 0.0701 M at equilibrium, what is the equilibrium concentration of HI, [HI]?

Answer with units:_____

3e. (10 pts) Consider the following disturbances to the system at equilibrium. In which direction will the reaction shift in order to reattain equilibrium? Circle: L for left, R for right and No for no shift.

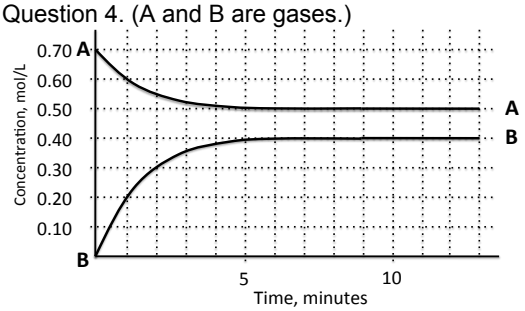
3a. Some more $I_2(g)$ is added.	L R No
3b. Some HI(g) is removed.	L R No
3c. The container size is decreased.	L R No
3d. The temperature is increased.	L R No
3e. A catalyst is added.	L R No

3f. (3 pts) What is the numerical value of K_c for:

$$HI(g) \rightleftharpoons \tfrac{1}{2} H_2(g) + \tfrac{1}{2} I_2(g)$$

K_c =

4. (2 pts each, unless noted) Use this graph for all of Question 4. (A and B are gases.)



4a. (1 pt) How long does the reaction take to reach equilibrium?

4b. Is the balanced reaction: A → 2 B? Yes No

4c. What is the numerical value for K_c?

4d. (1 pt) Is $K_p = K_c$? Yes No

4e-f. At t = 13 minutes, suppose the container size was decreased, causing [A] and [B] to increase.

4e. As equilibrium is re-established, which gas concentration, [A] or [B] will continue to increase from its value after the volume was changed? [A] [B]

4f. Would K_c increase, decrease or stay the same as equilibrium was reestablished? Incr Decr Stay same

4g. (3 pts) Circle all of the following equations that describe the relationship between kinetics and equilibrium

a. $k_{fwd} = k_{rev}$ b. $K_c = \frac{k_{fwd}}{k_{rev}}$ c. $rate_{fwd} = rate_{rev}$

5. (5 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) HF (E) $HClO_4$

6a (2 pts) Write the reaction that shows the dissociation of HCl in aqueous solution.

6b. (4 pts) What is the pH of a 3.77 x 10^{-4} M HCl solution?

Answer:_____

7 (2 pts) Write the equilibrium that shows the dissociation of HCN in aqueous solution.

8. (4 pts) Suppose 0.1083 g KOH(s) was dissolved in enough water to make 100 mL solution using a volumetric flask. Given pH + pOH = 14.00, calculate the $[OH^-]$ and pH of the solution.

Answers: $[OH^-]$ = _____ and pH = _____

9 (2 pts) Write the equilibrium that shows how the fluoride ion functions as a weak base in water.

10 (3 pts) Circle the most acidic of each pair of values:

10a. pH = 4.00 or pH = 6.00

10b. $[H_3O^+]$ = 2 x 10^{-3} M or $[H_3O^+]$ = 1 x 10^{-5} M

10c. $[H_3O^+]$ = 6 x 10^{-8} M or pH = 8.60

For DocM to complete:

Subtotal from exam: _____

Folder work: (20 max) _____

Total: _____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																1 H 1.01	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 97	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	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 131.30
55 Cs 132.91	56 Ba 137.33	57 La 138.91	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 195.09	79 Au 196.97	80 Hg 200.59	81 Ti 204.37	82 Pb 207.2	83 Bi 208.98	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.03	89 Ac 227															

Answers:

1a. two; 1b. Step 1; 1c. -20 kJ, 1d. 70 kJ; 1e. 35 kJ; 1f. 105 kJ; 1g. Step 1; 1h. Can't tell; 1i. No

2a. rate = $k[H_2][I_2]$

2b. the one on the right

2c. rate = $k[I_2]$

2d. No

2e. Yes, both H and I are intermediates

3a. $K_c = [HI]^2/[H_2][I_2]$

3b. [HI] = 0.0415 M; $[H_2] = [I_2]$ = 0.00156 M

3c. Q_c = 8.7, needs to shift right.

3d. [HI] = 0.766 M

3e. R R No L R

3f. K_c 0.0375

4a. 6 min; 4b. Yes; 4c. 0.32; 4d. No; 4e. [A]; 4f. Stay the same; 4g. b. and c

4g. b and c

5. (B) HNO_3 and (E) $HClO_4$

6a. $HCl(aq) + H_2O \rightarrow H_3O^+ + Cl^-$

6b. 3.42

7 $HCN(aq) + H_2O \underset{\rightarrow}{\longleftarrow} H_3O^+ + CN^-$

8. 0.0193 M $[OH^-]$; pH = 12.29

9 $F^-(aq) + H_2O \underset{\rightarrow}{\longleftarrow} OH^- + HF$

10 the first member of each pair