097 version ______ last name ______ first name ______ signature

McCord CH302
50375 / 50380

Exam 2

Spring 2017

Please also refer to the Periodic Table handout included with your exam bundle. Many conversion factors and physical constants are available there.

acid	formula	K_a
acetic	CH_3COOH	1.8×10^{-5}
benzoic	C_6H_5COOH	6.4×10^{-5}
butanoic	C_3H_7COOH	1.5×10^{-5}
chloroacetic	$CClH_2COOH$	1.4×10^{-3}
chlorous	$HClO_2$	1.2×10^{-2}
hydrocyanic	HCN	4.9×10^{-10}
hypobromous	$HBrO$	2.8×10^{-9}
hypochlorous	$HClO$	3.5×10^{-8}
nitrous	HNO_2	5.6×10^{-4}

base	formula	K_b
ammonia	NH_3	1.8×10^{-5}
aniline	$C_6H_5NH_2$	4.3×10^{-10}
ethylamine	$C_2H_5NH_2$	5.6×10^{-4}
hydrazine	N_2H_4	1.7×10^{-6}
methylamine	CH_3NH_2	4.4×10^{-4}
propylamine	$C_3H_7NH_2$	3.7×10^{-4}
triethylamine	$(C_2H_5)_3N$	5.6×10^{-4}
trimethylamine	$(CH_3)_3N$	6.5×10^{-5}
pyridine	C_5H_5N	1.8×10^{-9}

polyprotic acid	formula	K_a
phosphoric	H_3PO_4	1) 7.5×10^{-3}
		2) 6.2×10^{-8}
		3) 4.8×10^{-13}
sulfurous	H_2SO_3	1) 1.5×10^{-2}
		2) 1.0×10^{-7}

$K_w = 1.0 \times 10^{-14}$

$R = 8.314$ J/mol K

$R = 0.08206$ L atm / mol K

1 gal = 3.785 L

NOTE: Please keep your Exam copy intact (all pages still stapled). You must turn in your exam copy, bubble sheet, and scratch paper.

This print-out should have 30 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 4.0 points

For the reaction

$$Br_2(g) \rightleftharpoons 2\,Br(g)\,,$$

$\Delta G^\circ_r = +161.69\ \mathrm{kJ \cdot mol^{-1}}$ at 25°C. What is the value of K_p for this reaction?

1. 1.83×10^{-30}

2. 0.0378

3. 4.54×10^{-29}

4. 1.12×10^{-27}

002 2.0 points

The conjugate acid of HPO_4^{2-} is

1. $H_2PO_4^-$

2. H_3PO_4

3. HPO_4^{2-}

4. PO_4^{3-}

5. H^+

003 3.0 points

Given the hypothetical reaction below, predict what will happen when 1.0 mol of B(g) and 2.0 mol of C(s) are placed into an evacuated container.

$$A(g) \rightleftharpoons B(g) + 2C(s)$$

1. ΔG° will decrease until $\Delta G^\circ = 0$.

2. Nothing; the products are already formed, so no reaction occurs.

3. Q will increase until Q = K.

4. Q will decrease until Q = K.

004 4.0 points

The equilibrium constant for the reaction

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

has the value $K = 4.2 \times 10^{24}$ at 300 K.

Find the value of K for the reaction

$$3\,SO_2(g) + \frac{3}{2}\,O_2(g) \rightleftharpoons 3\,SO_3(g)$$

at the same temperature.

1. 8.6×10^{36}

2. 2.0×10^{12}

3. 7.0×10^{23}

4. 7.4×10^{73}

5. 1.8×10^{49}

005 3.0 points

What is the pH of a 0.047 M solution of HCN?

1. 4.82

2. 9.31

3. 4.65

4. 5.19

5. 5.32

6. 6.33

006 3.0 points

An olympic sized swimming pool has a volume of about 700 thousand gallons. Let's assume the pool is unbuffered and currently has a pH of 9.33 which is a bit high for swimming. Calculate how many gallons of muratic acid (aka: 10 M hydrochloric acid) will it take to adjust the pool back to neutrality?

1. 3.0 gal

2. 1.5 gal

3. 1.0 gal

4. 2.0 gal

5. 2.5 gal

6. >> 5 gal

---

007 3.0 points

Write the reaction quotient for

$$4\,\mathrm{Bi(s)} + 3\,\mathrm{O_2(g)} \rightarrow 2\,\mathrm{Bi_2O_3(s)}$$

1. $Q = P^3_{\mathrm{O_2}}$

2. $Q = \frac{2\,P_{\mathrm{Bi_2O_3}}}{4\,P_{\mathrm{Bi}}\,3\,P_{\mathrm{O_2}}}$

3. $Q = \frac{P^2_{\mathrm{Bi_2O_3}}}{P^4_{\mathrm{Bi}}\,P^3_{\mathrm{O_2}}}$

4. $Q = \frac{P^2_{\mathrm{Bi_2O_3}}}{P^4_{\mathrm{Bi}}}$

5. $Q = \frac{1}{P^3_{\mathrm{O_2}}}$

---

008 3.0 points

Bromothymol blue is an important indicator because it changes color around a neutral pH. It is yellow when protonated and blue when deprotonated. The full range of color change occurs between pH = 5.5 and pH = 7.5.

A few drops of bromothymol blue are placed in an unknown solution. The solution turns pure yellow. What is the BEST conclusion to make about this sample?

1. The solution is within a range of pH = 5.5 to pH = 6.5

2. The solution is within a range of pH = 5.5 to pH = 7.5

3. The solution has a pH less than 5.5

4. The solution has a pH = 7

5. The solution must be extremely acidic

6. The solution must be extremely basic

7. The solution has a pH greater than 7.5

---

009 3.0 points

A reaction is at equilibrium and then the entire mixture is compressed to half the original volume. As expected, the pressure initially doubles, but then falls slightly to a lower pressure. Which of the five generic reactions listed is the only one capable of this response?

1. $\mathrm{B(g)} \rightleftharpoons \mathrm{Z(g)}$

2. $\mathrm{A(g)} + \mathrm{C(g)} \rightleftharpoons 3\mathrm{D(g)}$

3. $\mathrm{A(g)} + \mathrm{B(g)} \rightleftharpoons 2\mathrm{C(g)}$

4. $2\mathrm{W(g)} + \mathrm{X(g)} \rightleftharpoons \mathrm{Y(g)} + 2\mathrm{Z(g)}$

5. $\mathrm{C(g)} + \mathrm{J(s)} \rightleftharpoons \mathrm{Y(g)}$

---

010 3.0 points

Consider the reaction

$$\mathrm{CO(g)} + 2\,\mathrm{H_2(g)} \rightleftharpoons \mathrm{CH_3OH(g)}$$

At room temperature, K is approximately 2×10^4, but at a higher temperature K is substantially smaller. Which of the following is true?

1. The reaction is endothermic.

2. At the higher temperature, more CH_3OH(g) is produced.

3. The reaction is exothermic.

4. The reaction becomes spontaneous at higher temperatures.

---

011 4.0 points

What is the concentration of H_3O^+ ions in a 0.10 M solution of $Ba(OH)_2$ at 25°C?

1. 2.5×10^{-13} M

2. 5.0×10^{-14} M

3. None of the other answers is correct.

4. 1.0×10^{-13} M

5. 1.0×10^{-1} M

---

012 4.0 points

A 500 mL sample of 0.50 M hypochlorous acid, HOCl, was titrated to the equivalence point with 0.50 M NaOH solution. What is the pH of the solution at the equivalence point?

1. 3.57

2. 10.43

3. 3.20

4. 10.82

5. 7.00

---

013 4.0 points

List the the following solution species in order of increasing base strength (weakest base to strongest base).

CN^- $(C_2H_5)_3N$ N_2H_4 BrO^-

1. $(C_2H_5)_3N$ BrO^- N_2H_4 CN^-

2. CN^- N_2H_4 BrO^- $(C_2H_5)_3N$

3. $(C_2H_5)_3N$ CN^- BrO^- N_2H_4

4. N_2H_4 BrO^- CN^- $(C_2H_5)_3N$

5. $(C_2H_5)_3N$ BrO^- CN^- N_2H_4

6. N_2H_4 CN^- BrO^- $(C_2H_5)_3N$

7. BrO^- $(C_2H_5)_3N$ N_2H_4 CN^-

8. CN^- N_2H_4 $(C_2H_5)_3N$ BrO^-

---

014 4.0 points

Chlorinating the terminal carbon of acetic acid makes the molecule more acidic. What is the pH of a 0.020 M chloroacetic acid ($CClH_2COOH$) solution?

1. 3.11

2. 2.33

3. 2.28

4. 2.80

5. 12.22

6. 1.70

---

015 4.0 points

Note: The K_p given in this problem is based on bar, not atm. Work the problem in bar.

Consider the following decomposition reaction at 700 K.

$$2\,CaSO_4(s) \rightarrow 2\,CaO(s) + 2\,SO_2(g) + O_2(g)$$

If $K_p = 0.032$ at this temperature, what will be the equilibrium overall pressure starting from pure $CaSO_4(s)$?

1. 0.40 bar

2. 0.20 bar

3. 0.60 bar

4. 0.011 bar

5. 0.22 bar

---

016 3.0 points

You have a 1.5 M solution of methylamine, CH_3NH_2. You expect the concentration of methylammonium ion, $CH_3NH_3^+$ in this solution to be

1. Slightly greater than 1.5 M

2. Much greater than 1.5 M

3. 1.5 M

4. Much lower than 1.5 M

5. Slightly lower than 1.5 M

---

017 3.0 points

Which response identifies the statements true of buffer solutions?

I) A buffer solution could consist of equal concentrations of ammonia and ammonium bromide.

II) A buffer solution could consist of equal concentrations of perchloric acid ($HClO_4$) and sodium perchlorate.

III) A buffer solution will change only slightly in pH upon addition of small amounts of acid or base.

IV) In a buffer solution containing benzoic acid (C_6H_5COOH) and sodium benzoate (NaC_6H_5COO) the species that reacts with added hydroxide ion is the benzoate ion.

1. II, III

2. Another combination

3. I, III

4. I, IV

5. II, III, IV

---

018 4.0 points

Consider the following reaction

$$A(g) + B(g) \rightleftharpoons 2C(g)$$

where equal partial pressures of A and B gases are put into a reaction vessel. After equilibrium is established, it is found that 80% of A and B have reacted. What is the value for K for this reaction?

1. 4

2. 16

3. 25

4. 80

5. 36

6. 1

7. 64

---

019 4.0 points

Which of the following chemical species would you expect to be the predominant form of sulfurous acid in a solution with a pH of 9 ?

1. HSO_3^-

2. $H_3SO_3^+$

3. H_2SO_3

4. SO_3^{2-}

---

020 3.0 points

Solution A has a H^+ concentration of 10^{-5} M. Solution B has a H^+ concentration of 10^{-3} M. Which one has a lower pH, and which one contains more OH^- ions?

1. B; B

2. B; A

3. A; B

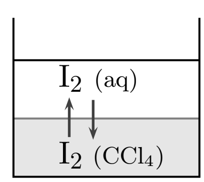
4. A; A

---

021 4.0 points

A special type of equilibrium is between two different solvents for the same solute. In this case the solute is iodine (I_2). Iodine is more soluble in carbon tetrachloride (CCl_4) than in water.

Water and CCl_4 are immiscible and separate into 2 distinct liquid phases with the less dense water on top (see figure).



The I_2 will reach equilibrium across the phase boundary and the equilibrium constant, K_c can be determined.

The iodine is initially only in the aqueous solution at a concentration of 1.2×10^{-3} M. After the CCl_4 is added, and the system reaches equilibrium, the concentration in the aqueous phase has dropped to 1.6×10^{-5} M. Calculate the equilibrium constant, K_c for this partitioning between the two phases. Specifically for

$$I_2(aq) \rightleftharpoons I_2(CCl_4)$$

1. 7.4×10^{1}

2. 1.4×10^{2}

3. 9.3×10^{1}

4. 6.2×10^{4}

5. 1.4×10^{-2}

---

022 3.0 points

As a reaction proceeds to the equilibrium state at constant temperature, which of the following statements is correct?

1. The value of $\Delta G°$ is changing until it equals zero.

2. The value of Q is changing and headed towards the minimum value possible.

3. The overall free energy of the system is decreasing until a minimum is reached.

4. The reaction will proceed such that the activities of the products equals the activities of the reactants.

5. The value of K will change until it equals one.

---

023 3.0 points

You mix 10 mL of 3M LiOH with 10 mL of 3M HNO_2 . The final solution will be

1. Neutral

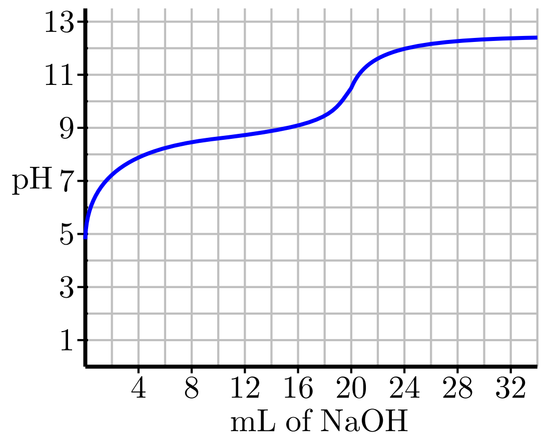
2. Acidic

3. Basic

---

024 (part 1 of 3) 3.0 points

A sample of 100 mL of a weak acid (HA) solution was titrated with 0.065 M NaOH. The pH curve for this titration is shown.



What is the concentration of the original weak acid solution (the 100 mL) ?

1. 0.33 M

2. 0.065 M

3. 0.013 M

4. 0.016 M

5. 0.010 M

---

025 (part 2 of 3) 2.0 points

What is the pH at the equivalence point of this titration?

1. 7.00

2. 8.6

3. 10.6

4. 9.2

5. 12.1

026 (part 3 of 3) 3.0 points

Which of these acids and bases could be the solution that was titrated?

1. hypochlorous acid

2. hypoiodous acid

3. chlorous acid

4. hypobromous acid

5. nitrous acid

6. butanoic acid

027 3.0 points

In the following equation, water is acting as a(n)

$C_6H_5COOH(aq) + H_2O(l) \rightleftharpoons C_6H_5COO^-(aq) + H_3O^+(aq)$

1. Neither

2. Base

3. Acid

028 4.0 points

A buffer was prepared by mixing 0.40 moles of methylamine (CH_3NH_2) and 0.40 moles of methylammonium chloride (CH_3NH_3Cl) to form an aqueous solution with a total volume of 800 mL. After that solution came to equilibrium, 0.10 moles of HBr was added to the buffer solution. What is the new pH of the solution?

1. 5.47

2. 10.64

3. 3.13

4. 10.87

5. 3.36

6. 10.42

7. 3.58

029 3.0 points

The $\Delta H°$ for the autoionization of water is 55.7 kJ/mol. Which of the following is/are true regarding the autoionization of pure water?

I) The concentration of H_3O^+ will be greater at 37°C

II) $[OH^-] = [H_3O^+]$ at all temperatures

III) K_w is equal to 1 x 10^{-14} at all temperatures

IV) The concentration of H_3O^+ will be less at 37°C

1. II and IV

2. II only

3. I and II

4. III only

5. I, II, and III

6. II, II, and IV

030 4.0 points

What is the percent ionization for a 0.50 M solution of trimethylamine, $(CH_3)_3N$?

1. 100%

2. 4.6%

3. 0.57%

4. 1.1%

5. 2.1%

6. 1.8%