

## Recitation Worksheet 12 – Exam 4 Review

Name:

MyID:

### Instructions:

1. This recitation worksheet is for the exam 4 review.
2. You **do not need** to submit it to GradeScope.
3. The answer key has been posted with this worksheet to eLC.
4. The **recitation session in the exam week (Apr 17-20) is still mandatory**. The attendance will be recorded.

1. What structural features of a molecule may affect the pKa of an acid?

- A. Electronegativity
- B. The strength of the bond to the acidic hydrogen
- C. Inductive effect
- D. Resonance destabilization
- E. All the above

2. Which of the following acidity relationships is true?

- A.  $\text{H}_2\text{SO}_3 > \text{H}_2\text{SO}_4$
- B.  $\text{H}_2\text{PO}_4^- > \text{HPO}_4^{2-}$
- C.  $\text{HF} > \text{HClO}_4$
- D.  $\text{H}_2\text{CO}_3 > \text{HNO}_3$
- E. None of these

3. Which acid of the set has the strongest conjugate base?

- A.  $\text{CH}_4$
- B.  $\text{NH}_3$
- C.  $\text{H}_2\text{S}$
- D.  $\text{HCl}$

4. Which of the following acids will be the strongest?

- A)  $\text{H}_2\text{SO}_4$     B)  $\text{HSO}_4^-$     C)  $\text{H}_2\text{SO}_3$     D)  $\text{H}_2\text{SeO}_4$     E)  $\text{HSO}_3^-$

### Recitation Worksheet 12 – Exam 4 Review

5. For which of the pairs of acids is the stronger acid listed first? (Select all that apply).

☐

A. HI or HCl

B. HF or HBr

C.  $\text{HClO}_3$  or  $\text{HBrO}_3$

D.  $\text{HOSO}_2\text{CF}_3$  or  $\text{HOSO}_2\text{CH}_3$

6. Which of the following acids will be the strongest?

☐

I.  $\text{CH}_3\text{OH}$

II.  $\text{CH}_3\text{SH}$

III.  $\text{CH}_3\text{PH}_2$

7. Predict which one is the stronger acid of each of the following pairs of acids?

☐

A.  $\text{H}_2\text{SiO}_3$  or  $\text{H}_3\text{PO}_4$

☐

B.  $\text{H}_2\text{CO}_3$  or  $\text{H}_2\text{BO}_3$

☐

C.  $\text{HOClO}$  or  $\text{HOBr}$

8. Arrange the following binary compounds in order of increasing acid strength.

☐

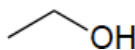
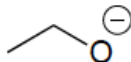
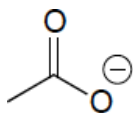
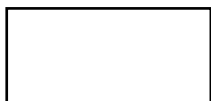
I.  $\text{H}_2\text{Te}$

II. HI

III.  $\text{H}_2\text{S}$

### Recitation Worksheet 12 – Exam 4 Review

9. Rank these molecules in terms of decreasing basicity (strongest to weakest base):



I.

II.

III.

A. I > II > III

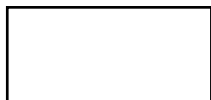
B. II > III > I

C. III > II > I

D. I > III > II

E. II > I > III

10. Which of these species is probably the weakest acid?



A. HCl

B.  $\text{H}_3\text{PO}_4$

C.  $\text{H}_2\text{PO}_4^-$

D.  $\text{HPO}_4^{2-}$

E.  $\text{HNO}_3$

11. Given the following acids and  $K_a$  values:

$\text{HClO}_4$   
 $1 \times 10^7$

$\text{HOAc}$   
 $1.76 \times 10^{-5}$

$\text{HCN}$   
 $4.93 \times 10^{-10}$

$\text{HF}$   
 $3.53 \times 10^{-4}$

What is the order of increasing base strength?



A.  $\text{CN}^-$ ,  $\text{F}^-$ ,  $\text{OAc}^-$ ,  $\text{ClO}_4^-$

B.  $\text{CN}^-$ ,  $\text{OAc}^-$ ,  $\text{F}^-$ ,  $\text{ClO}_4^-$

C.  $\text{CN}^-$ ,  $\text{ClO}_4^-$ ,  $\text{F}^-$ ,  $\text{OAc}^-$

D.  $\text{ClO}_4^-$ ,  $\text{OAc}^-$ ,  $\text{CN}^-$ ,  $\text{F}^-$

E.  $\text{ClO}_4^-$ ,  $\text{F}^-$ ,  $\text{OAc}^-$ ,  $\text{CN}^-$

### Recitation Worksheet 12 – Exam 4 Review

12. A solution is prepared by dissolving 0.32 mol of  $\text{CH}_3\text{CH}_2\text{NH}_3\text{Cl}$  in 1.00 L of 1.5 M  $\text{CH}_3\text{CH}_2\text{NH}_2$ . If 10. mL of 0.11 M HCl is added to this solution, the pH of the solution will slightly \_\_\_\_\_ because the HCl reacts with the \_\_\_\_\_ present in the solution.

- A. Increase,  $\text{CH}_3\text{CH}_2\text{NH}_3^+$
- B. Increase,  $\text{CH}_3\text{CH}_2\text{NH}_2$
- C. Decrease,  $\text{CH}_3\text{CH}_2\text{NH}_2$
- D. Decrease,  $\text{CH}_3\text{CH}_2\text{NH}_3^+$

13. Identify the **false** statement regarding a solution that contains 0.20 moles of hypochlorous acid.

- A. Adding NaOH will increase the dissociation of HOCl, and decrease  $[\text{H}^+]$
- B. Adding HCl will decrease the dissociation of HOCl and decrease  $[\text{OCl}^-]$
- C. Adding NaOCl will increase the dissociation of the original HOCl, and will increase  $[\text{H}^+]$
- D. Adding NaCl will not affect either the dissociation of the original HOCl or the solution pH

14. What volume of 0.80 M HCl will be required to titrate 36.2 grams of NaBrO to the equivalence point?

- A. 150 mL
- B. 308 mL
- C. 381 mL
- D. 258 mL
- E. None of the above

15. To 60.0 mL of a solution that contains 0.80 M NaF and 0.80 M HF was added 20.0 mL of 0.40 M HCl. Calculate the moles of HF and the concentration of HF after addition.

- A. 0.056 moles, 0.70 M
- B. 0.056 moles, 0.93 M
- C. 0.048 moles, 0.60 M
- D. 0.040 moles, 0.67 M
- E. none are correct.

## Recitation Worksheet 12 – Exam 4 Review

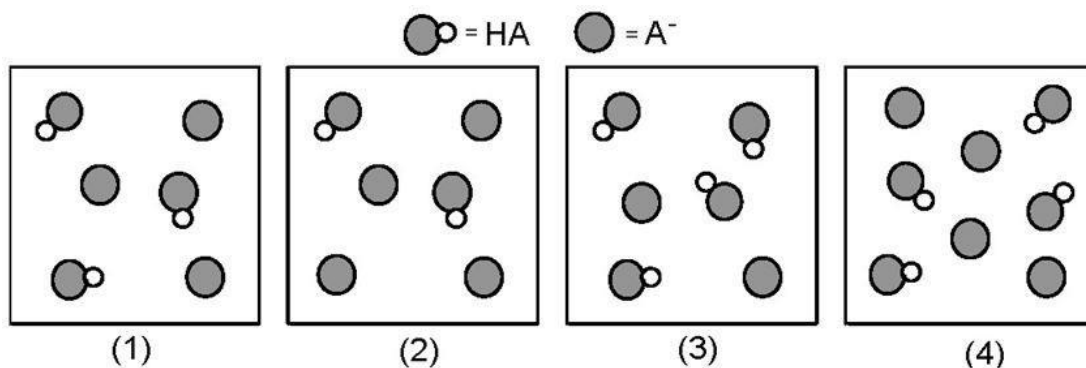
16. TRIS  $\{(\text{HOCH}_2)_3\text{CNH}_2\}$  is one of the most common buffers used in biochemistry. A solution is prepared by adding enough TRIS and 12 M  $\text{HCl}(\text{aq})$  to give 1.00 L of solution with  $[\text{TRIS}] = 0.30 \text{ M}$  and  $[\text{TRISH}^+] = 0.60 \text{ M}$ . What is the pH of this buffered system if the  $\text{p}K_b$  is 5.92?

- A. 5.92
- B. 6.22
- C. 7.78
- D. 8.08

17. All of the following solutions would be considered buffers **except**

- A.  $\text{CH}_3\text{COOH} / \text{CH}_3\text{COO}^-$ .
- B.  $\text{NaCl} / \text{HCl}$ .
- C.  $\text{H}_2\text{PO}_4^- / \text{HPO}_4^{2-}$ .
- D.  $\text{HPO}_4^{2-} / \text{PO}_4^{3-}$ .

18. These pictures represent solutions that contain a weak acid HA ( $\text{p}K_a = 5.0$ ) and its sodium salt NaA. Unshaded spheres represent H atoms and shaded spheres represent  $\text{A}^-$  ions. ( $\text{Na}^+$ ,  $\text{H}_3\text{O}^+$ ,  $\text{OH}^-$ , and solvent  $\text{H}_2\text{O}$  molecules have been omitted for clarity.)



19. Which solution has the greatest buffer capacity?

- E. (1)
- F. (2)
- G. (3)
- H. (4)

### Recitation Worksheet 12 – Exam 4 Review

20. Which titration curve corresponds to an initial pH of 10.7 and an equivalence point at pH = 4.5?

- A. A strong acid to which strong base is added
- B. A strong base to which strong acid is added
- C. A weak acid to which strong acid is added
- D. A weak base to which strong acid is added
- E. A weak base to which strong base is added

21. What is the percent dissociation of glycine if the solution has a pH = 8.60 and a  $pK_a = 9.60$ ?

- A. 50
- B. 9%
- C. 5%
- D. 1%

22. Twenty-five milliliters of 0.10 M HCl(aq) is titrated with 0.10 M NaOH(aq). What is the pH after 15 mL of NaOH(aq) has been added?

- A. 1.4
- B. 1.2
- C. 1.0
- D. 2.0
- E. 1.6

23. In a titration experiment, it was determined that a 50.0 mL sample of  $\text{HNO}_3$  required 66.0 mL of 0.80 M NaOH to reach the equivalence point. What was the molarity of the  $\text{HNO}_3$ ?

- A. 0.61 M
- B. 0.86 M
- C. 1.06 M
- D. 1.24 M
- E. none of these are correct

### Recitation Worksheet 12 – Exam 4 Review

24.  $\text{HN}_3$  has  $K_a = 2.0 \times 10^{-5}$ . What is the concentration of  $\text{N}_3^-$  in a solution that is 0.50 M in  $\text{HN}_3$  and 0.40 M in  $\text{HNO}_3$ ?

- A.  $3.5 \times 10^{-3}$
- B.  $2.5 \times 10^{-5}$
- C.  $2.0 \times 10^{-6}$
- D.  $8.0 \times 10^{-6}$
- E. None of these are correct

25. Which combination will give a pH of lower than 7.00 at the equivalence point?

- A.  $\text{HClO}_4 + \text{NaF}$
- B.  $\text{HNO}_3 + \text{KOH}$
- C.  $\text{NH}_4\text{Cl} + \text{NaOH}$
- D.  $\text{HF} + \text{NaOH}$
- E. None of these are correct

26. Which is a net ionic equation for the neutralization of a weak acid with a strong base?

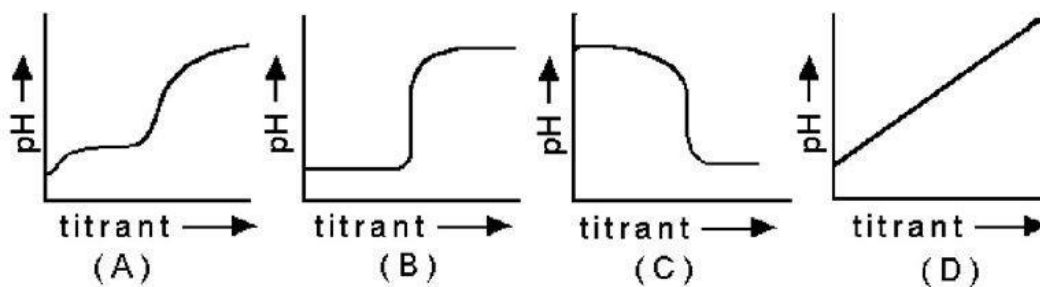
- A.  $\text{HBr}(aq) + \text{NaOH}(aq) \rightleftharpoons \text{H}_2\text{O}(l) + \text{NaBr}(aq)$
- B.  $\text{H}_3\text{O}^+(aq) + \text{OH}^-(aq) \rightleftharpoons 2 \text{H}_2\text{O}(l)$
- C.  $\text{HF}(aq) + \text{LiOH}(aq) \rightleftharpoons \text{H}_2\text{O}(l) + \text{LiF}(aq)$
- D.  $\text{HF}(aq) + \text{OH}^-(aq) \rightleftharpoons \text{H}_2\text{O}(l) + \text{F}^-(aq)$

27. What is the hydronium ion concentration in a solution prepared by mixing 50.00 mL of 0.10 M HCN with 50.00 mL of 0.010 M NaCN? Assume that the volumes of the solutions are additive and that  $K_a = 4.9 \times 10^{-10}$  for HCN.

Recitation Worksheet 12 – Exam 4 Review

- A.  $4.9 \times 10^{-11} \text{ M}$
- B.  $4.9 \times 10^{-10} \text{ M}$
- C.  $4.9 \times 10^{-9} \text{ M}$
- D.  $7.0 \times 10^{-6} \text{ M}$

28.



I. What is the characteristic pH-titrant curve for the titration of a strong acid by a strong base?

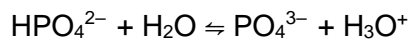
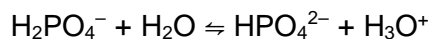
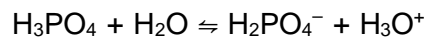
II. What is the characteristic pH-titrant curve for the titration of a strong base by a strong acid?

III. What is the characteristic pH-titration curve for the titration of a weak acid by a strong base?

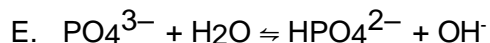
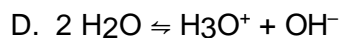
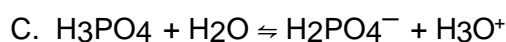
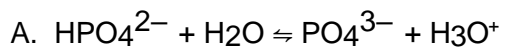


## Recitation Worksheet 12 – Exam 4 Review

29. Phosphoric acid is a triprotic acid, ionizing in sequential steps:



Which equilibrium is most important in determining the pH of a solution of sodium phosphate?



30. What is the pH of a solution prepared by mixing 50.00 mL of 0.10 M  $\text{NH}_3$  with 20.00 mL of 0.10 M  $\text{NH}_4\text{Cl}$ ?

$K_b = 1.8 \times 10^{-5}$  for  $\text{NH}_3$ .

31. Solutions of sodium salts of the acids in the table are prepared with an initial concentration of 0.500 M.

Which solution will have the highest pH and be the most basic?

### Acid    pKa

HA      4.00

HB      7.00

HC      10.00

HD      11.00

A. NaA

B. NaB

C. NaC

D. NaD

E. All will have the same pH because the concentrations are the same.

### Recitation Worksheet 12 – Exam 4 Review

32. Which of the groups, A–D, consist of salts that all form basic solutions in water?

- A.  $\text{NaNO}_3$ ,  $\text{NH}_4\text{CN}$ ,  $\text{NaOOCCH}_3$ ,  $\text{NH}_4\text{Cl}$
- B.  $\text{NaHCO}_3$ ,  $\text{NaF}$ ,  $\text{NH}_4\text{Cl}$ ,  $\text{Na}_2\text{SO}_3$
- C.  $\text{Na}_2\text{CO}_3$ ,  $\text{KCl}$ ,  $\text{NaOOCCH}_3$ ,  $\text{NH}_4\text{Cl}$
- D.  $\text{Na}_2\text{CO}_3$ ,  $\text{NaF}$ ,  $\text{NaOOCCH}_3$ ,  $\text{NaCN}$
- E. All of the above.

33. Which one of these is correct?

- A.  $\text{K}_2\text{SO}_3$  is a stronger base than  $\text{KHSO}_3$ .
- B.  $\text{Na}_2\text{HPO}_4$  is a weaker base than  $\text{NaH}_2\text{PO}_4$ .
- C.  $\text{K}_2\text{CO}_3$  is a weaker base than  $\text{KHCO}_3$ .
- D.  $\text{NaHSO}_3$  is a stronger acid than  $\text{NaHSO}_4$ .
- E. All of these statements are correct.

34. An aqueous solution of an unknown acid had a pH of 3.70. Titration of a 25.0 mL aliquot of the acid solution required 21.7 mL of 0.104 M aqueous sodium hydroxide for complete reaction. Assuming that the acid is monoprotic, what is its ionization constant?

35. Which of these mixtures would result in a buffered solution when 1.0 L of each of the two solutions are mixed.

- A. 0.2 M  $\text{HNO}_3$  and 0.2 M  $\text{NaNO}_3$
- B. 0.2 M  $\text{HNO}_3$  and 0.4 M  $\text{HF}$
- C. 0.2 M  $\text{HNO}_3$  and 0.4 M  $\text{NaF}$
- D. 0.2 M  $\text{HNO}_3$  and 0.4 M  $\text{NaOH}$

### Recitation Worksheet 12 – Exam 4 Review

36. The pH of a solution of  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$  is approximately 7. The best explanation is:

- A. This salt does not react with water.
- B. Ammonium acetate is a weak electrolyte.
- C. All salts of weak acids and weak bases are neutral.
- D. Aqueous ammonia and acetic acid have approximately equal ionization constants.
- E. The salt is a product of a strong acid and a strong base.

37. What is the  $[\text{HPO}_4^{2-}]$  of a solution labeled "0.10 M phosphoric acid"?

$$[K_{a1} = 7.1 \times 10^{-3}; K_{a2} = 6.3 \times 10^{-8}; K_{a3} = 4.2 \times 10^{-13}]$$

38. A pH 4.88 buffer was prepared by dissolving 0.10 mol of benzoic acid ( $K_a = 6.3 \times 10^{-5}$ ) and 0.50 mol of sodium benzoate in sufficient pure water to form a 1.00 L solution. To a 70.0 mL aliquot of this solution was added 2.00 mL of 2.00 M aqueous HI solution. What was the pH of the new 72.0 mL solution?

### Recitation Worksheet 12 – Exam 4 Review

39. What is the pH of the solution when 52.60 mL of 0.35 M acetic acid is added to 22.08 mL of 0.20 M NaOH? The  $K_a$  for acetic acid is  $1.8 \times 10^{-5}$ .

40. A 0.500 g sample of an unknown substance was titrated with a 0.1 M HCl solution. Another 0.500 g sample of it was titrated with a 0.1 M NaOH solution. The resulting titration curves are illustrated here. Given the following possibilities, what is the sample?

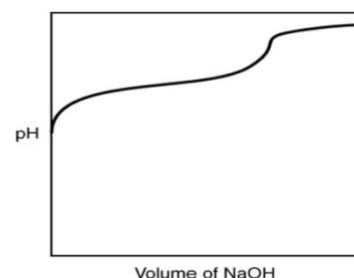
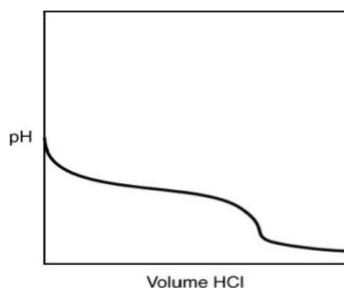
A.  $\text{Na}_2\text{CO}_3$

B.  $\text{CO}_2$

C.  $\text{NaHCO}_3$

D.  $\text{H}_2\text{CO}_3$

E. There is no way to tell.



41. Consider 1.00 L of a solution initially containing 0.500 mol ammonia ( $\text{NH}_3$ ) and 0.300 mol of ammonium ion ( $\text{NH}_4^+$ ). What is the pH after addition of 40 mL of 0.800M NaOH to this solution? ( $\text{NH}_4^+$   $K_a = 5.6 \times 10^{-10}$ )?

## Recitation Worksheet 12 – Exam 4 Review

42. Of the following substances, which one(s) will form basic solutions (select all that apply).  
 ( $\text{H}_2\text{CO}_3$   $K_{a1} = 4.4 \times 10^{-7}$ ,  $K_{a2} = 4.7 \times 10^{-11}$ ;  $\text{H}_2\text{S}$   $K_{a1} = 1.1 \times 10^{-7}$ ,  $K_{a2} = 1.0 \times 10^{-19}$ )

**NaHS**

**$\text{Cu}(\text{NO}_3)_2$**

**$\text{KHCO}_3$**

**NaF**

- A. NaHS,  $\text{Cu}(\text{NO}_3)_2$
- B.  $\text{KHCO}_3$ , NaHS
- C. NaF only
- D. NaF,  $\text{KHCO}_3$
- E. NaHS,  $\text{KHCO}_3$  and NaF

43. An aqueous solution of NaF is prepared by dissolving 0.350 mol of NaF in sufficient water to yield 1.0 L of solution. The pH of the solution was 8.93 at 25.0 °C. What is the  $K_b$  of  $\text{F}^-$ ?

x 10

44. The acid-dissociation constant,  $K_a$ , for an unknown acid HA is  $4.57 \times 10^{-3}$ . What is the base-dissociation constant,  $K_b$ , for the unknown anion  $\text{A}^-$ ?

x 10

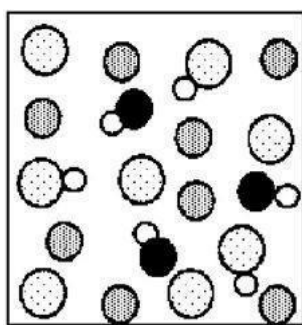
## Recitation Worksheet 12 – Exam 4 Review

45. A certain acid, HA, has a  $K_a$  given by:

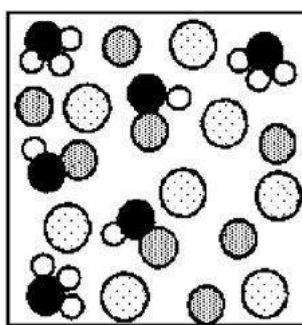


What is the pH of a 0.345 M aqueous solution of the acid's potassium salt, KA, which undergoes the hydrolysis reaction?

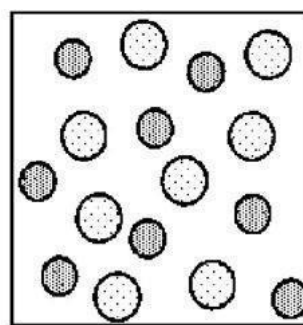
46. The pictures represent solutions of three salts MA; water molecules have been omitted for clarity. Dotted spheres represent  $\text{A}^-$  ions; gray spheres represent  $\text{M}^+$  ions; black spheres represent oxygen atoms; and unshaded spheres represent hydrogen atoms.



(1)



(2)



(3)

Which picture represents a basic salt?

- A. (1) Only drawing with hydroxide ions present.
- B. (2)
- C. (3)
- D. none of these

### Recitation Worksheet 12 – Exam 4 Review

47. Which of the following salts will produce an acidic solution?

- A)  $\text{Sr}(\text{ClO}_4)_2$
- B)  $\text{KBr}$
- C)  $\text{NH}_4\text{I}$
- D)  $\text{K}_2\text{CO}_3$
- E)  $\text{NaNO}_3$

48. Calculate the pH of a 0.100 M  $\text{CH}_3\text{NH}_3\text{Cl}$  solution.  $K_b$  for methylamine,  $\text{CH}_3\text{NH}_2$ , is  $3.7 \times 10^{-4}$ .

49. Calculate the pH of a 0.800 M  $\text{KBrO}$  solution.  $K_a$  for hypobromous acid,  $\text{HBrO}$ , is  $2.0 \times 10^{-9}$ .

## Recitation Worksheet 12 – Exam 4 Review

50. Ascorbic acid,  $\text{H}_2\text{C}_6\text{H}_6\text{O}_6$  is a diprotic acid, with  $K_{a1} = 1.0 \times 10^{-5}$  and  $K_{a2} = 5.0 \times 10^{-12}$ . It is often abbreviated as **H2Asc**. Using this abbreviation to write out the equilibria of this acid with water. If you type your answers in the pdf, please use “^” for superscripts and “\_” for subscripts.



51. Predict whether each of the following salt solutions will be **A)** acidic, **B)** basic, or **C)** neutral. Remember that ionic compounds dissociate completely in water.

$$K_a \text{ for HNO}_2 = 4.0 \times 10^{-4}$$

$$K_b \text{ for NH}_3 = 1.8 \times 10^{-5}$$

$$\text{H}_3\text{PO}_4: K_{a1} = 7.5 \times 10^{-3}$$

$$K_{a2} = 6.2 \times 10^{-8}$$

$$K_{a3} = 4.8 \times 10^{-13}$$

☐

a.  $\text{NaCl (aq)}$

☐

b.  $\text{NH}_4\text{NO}_3 \text{ (aq)}$

☐

c.  $\text{NaCH}_3\text{CO}_2 \text{ (aq)}$

☐

d.  $\text{NH}_4\text{NO}_2 \text{ (aq)}$

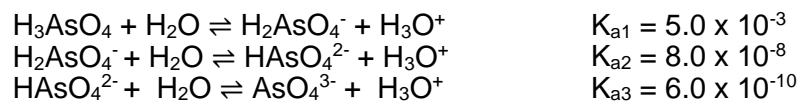
☐

e.  $(\text{NH}_4)_3\text{PO}_4 \text{ (aq)}$



## Recitation Worksheet 12 – Exam 4 Review

52. Arsenic acid,  $\text{H}_3\text{AsO}_4$  is a triprotic acid. It has three equilibrium associated with its reaction with water:



If we have a 5.00 M solution of  $\text{H}_3\text{AsO}_4$ , what are the concentrations of all of the species present?

a. First, calculate the following concentrations using the first ionization.

$$[\text{H}_3\text{AsO}_4] = \boxed{\phantom{000000}} \text{ M}$$

$$[\text{H}_2\text{AsO}_4^-] = \boxed{\phantom{000000}} \text{ M}$$

$$[\text{H}_3\text{O}^+] = \boxed{\phantom{000000}} \text{ M}$$

b. What is the pH of this solution?

$$\text{pH} = \boxed{\phantom{000000}}$$

c. Calculate the  $[\text{HAsO}_4^{2-}]$  by solving for  $K_{a2}$

$$[\text{HAsO}_4^{2-}] = \boxed{\phantom{000000}} \text{ M}$$

d. Calculate the  $[\text{AsO}_4^{3-}]$  by solving for  $K_{a3}$ ?

$$[\text{AsO}_4^{3-}] = \boxed{\phantom{000000}} \text{ M}$$

**Recitation Worksheet 12 – Exam 4 Review**

53. For which of these salts does the solubility increase at low pH?

- A.  $\text{Ca}(\text{NO}_3)_2$
- B.  $\text{CaF}_2$
- C.  $\text{CaCl}_2$
- D.  $\text{CaBr}_2$
- E.  $\text{CaI}_2$

54. Copper(II) fluoride has a solubility of 0.0020 mol/L. What is the value of  $K_{\text{sp}}$ ?

- A.  $1.8 \times 10^{-7}$
- B.  $4.0 \times 10^{-6}$
- C.  $3.2 \times 10^{-8}$
- D.  $8.0 \times 10^{-9}$
- E. None of these are correct.

55. The  $K_{\text{sp}}$  of  $\text{AgCl}$  is  $1.7 \times 10^{-10}$ . How many moles of  $\text{MnCl}_2$  can be dissolved in one liter of an aqueous solution in which  $[\text{AgNO}_3] = 3.4 \times 10^{-4} \text{ M}$  before a precipitate appears?

- A.  $5.0 \times 10^{-7} \text{ mol}$
- B.  $5.8 \times 10^{-14} \text{ mol}$
- C.  $2.4 \times 10^{-7} \text{ mol}$
- D.  $2.0 \times 10^6 \text{ mol}$
- E.  $2.5 \times 10^{-7} \text{ mol}$

### Recitation Worksheet 12 – Exam 4 Review

56. When equal volumes of the indicated aqueous solutions are mixed, precipitation should occur only for:

<u>Salt</u>	<u>K<sub>sp</sub></u>
barium fluoride	$1.0 \times 10^{-6}$
calcium carbonate	$2.8 \times 10^{-9}$
calcium fluoride	$5.3 \times 10^{-9}$
magnesium fluoride	$3.7 \times 10^{-9}$
silver carbonate	$8.5 \times 10^{-12}$

☐

- A.  $2 \times 10^{-5} \text{ M Ag}^+ + 2 \times 10^{-5} \text{ M CO}_3^{2-}$
- B.  $2 \times 10^{-4} \text{ M Ca}^{2+} + 2 \times 10^{-4} \text{ M CO}_3^{2-}$
- C.  $2 \times 10^{-5} \text{ M Ca}^{2+} + 2 \times 10^{-3} \text{ M F}^-$
- D.  $2 \times 10^{-5} \text{ M Mg}^{2+} + 2 \times 10^{-6} \text{ M F}^-$
- E.  $2 \times 10^{-3} \text{ M Ba}^{2+} + 2 \times 10^{-3} \text{ M F}^-$

## Recitation Worksheet 12 – Exam 4 Review

57. Calculate the concentration of copper(II) ion in  $\text{Cu}(\text{OH})_2$ , in ppm, that can remain at equilibrium in a solution having a  $[\text{OH}^-] = 1.0 \times 10^{-4} \text{ M}$ .  $K_{\text{sp}} = 1.6 \times 10^{-19}$ . Density of solution is 1.0 g/mL.

58. To a concentrated buffer of pH 9.0 was added an equal volume of an aqueous solution that was 0.20 M in each of the ions  $\text{Ca}^{2+}$ ,  $\text{Cd}^{2+}$ , and  $\text{Cu}^{2+}$ . The expected precipitate would consist of:

salt:    calcium hydroxide    cadmium hydroxide    copper(II) hydroxide

$K_{\text{sp}}$ :     $4.0 \times 10^{-6}$              $2.0 \times 10^{-14}$              $1.8 \times 10^{-19}$

- A. only  $\text{Ca}(\text{OH})_2$
- B. only  $\text{Cd}(\text{OH})_2$
- C. only  $\text{Cu}(\text{OH})_2$
- D. only  $\text{Cd}(\text{OH})_2$  and  $\text{Cu}(\text{OH})_2$
- E.  $\text{Ca}(\text{OH})_2$ ,  $\text{Cd}(\text{OH})_2$ , and  $\text{Cu}(\text{OH})_2$

59. A small amount of solid magnesium hydroxide is shaken vigorously in a test tube almost full of water until no further change occurs and most of the solid settles out. The resulting solution is:

- A. concentrated and saturated
- B. dilute and saturated
- C. dilute and unsaturated
- D. dilute and supersaturated
- E. concentrated and supersaturated

60. What is the molar solubility of  $\text{Mg}(\text{OH})_2(\text{s})$  in a basic aqueous solution with a pH of 12.50?  $K_{\text{sp}}$  for  $\text{Mg}(\text{OH})_2(\text{s})$  is  $5.6 \times 10^{-12}$ .

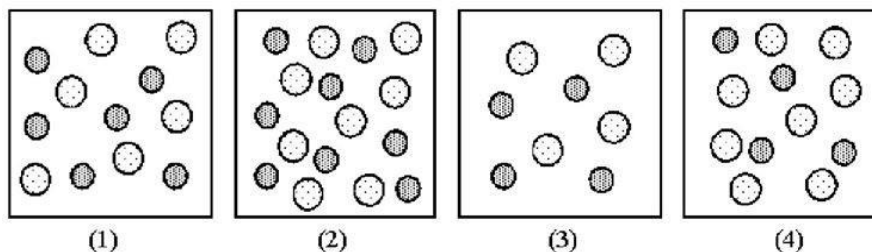
- A.  $1.8 \times 10^{-10} \text{ mol/L}$
- B.  $5.6 \times 10^{-9} \text{ mol/L}$
- C.  $2.4 \times 10^{-6} \text{ mol/L}$
- D.  $1.1 \times 10^{-4} \text{ mol/L}$

# Recitation Worksheet 12 – Exam 4 Review

61. The dissolution of barium hydroxide in water is an endothermic process with a  $K_{sp}$  of  $5.00 \times 10^{-4}$  at 298 K. Which of these will increase the solubility?

- A. Barium hydroxide is added to the solution.
- B. Sodium hydroxide (NaOH) is added to the solution.
- C. The temperature is decreased.
- D. HCl is added to the mixture.

62. The pictures represent solutions of CuS and may also contain ions other than  $\text{Cu}^{2+}$  and  $\text{S}^{2-}$  which are not shown. Gray spheres represent  $\text{Cu}^{2+}$  ions and dotted spheres represent  $\text{S}^{2-}$  ions.



If solution (1) is a saturated solution of CuS, which of solutions (2)-(4) are unsaturated?

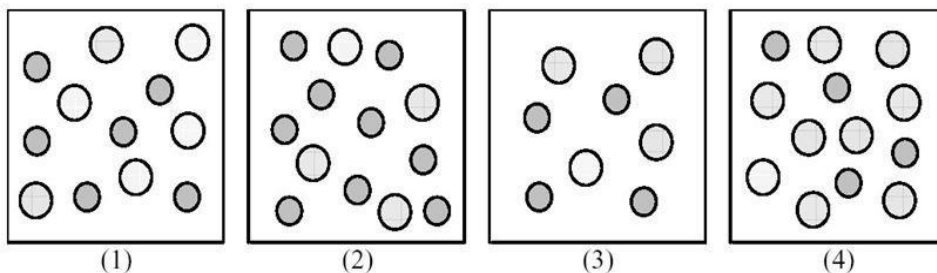
- A. only (2)
- B. only (3)
- C. only (4)
- D. (3) and (4)

63. In which of the following pairs is the oxidation number for the underlined element **incorrect**?

- A. Mn $\text{O}_4^-$ /(+7)
- B. S $\text{O}_4^{2-}$ /(+4)
- C. N $\text{H}_4^+$ /(-3)
- D. N $\text{O}_3^-$ /(+5)
- E. Cr $_2\text{O}_7^{2-}$ /(+6)

## Recitation Worksheet 12 – Exam 4 Review

64. The pictures represent solutions of AgCl and may contain ions other than  $\text{Ag}^+$  and  $\text{Cl}^-$  that are not shown. Gray spheres represent  $\text{Ag}^+$  ions and dotted spheres represent  $\text{Cl}^-$  ions.



If solution (1) is a saturated solution of AgCl, which of solutions (1)-(4) represents the solution after a small amount of  $\text{HNO}_3$  is added and equilibrium is restored?

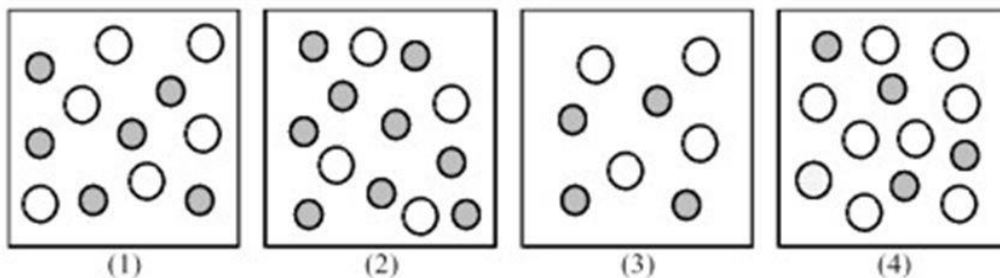
- A. (1)
- B. (2)
- C. (3)
- D. (4)

65. Identify the reaction(s) that are redox reactions:

- A.  $\text{HOCl(aq)} + \text{NaOH(aq)} \rightarrow \text{NaOCl(aq)} + \text{H}_2\text{O(l)}$
- B.  $5 \text{I}^-\text{(aq)} + \text{IO}_3^-\text{(aq)} + 6 \text{H}^+\text{(aq)} \rightarrow 3 \text{I}_2\text{(s)} + 3 \text{H}_2\text{O(l)}$
- C.  $2 \text{NaCl(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow 2 \text{HCl(g)} + \text{Na}_2\text{SO}_4\text{(s)}$
- D.  $\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$
- E.  $2 \text{H}_2\text{O}_2\text{(aq)} \rightarrow 2 \text{H}_2\text{O(l)} + \text{O}_2\text{(g)}$

# Recitation Worksheet 12 – Exam 4 Review

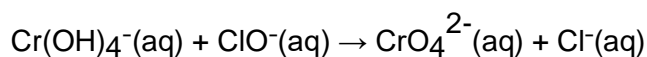
66. The pictures represent solutions of  $\text{CaCO}_3$ . The solution may contain ions other than  $\text{Ca}^{2+}$  and  $\text{CO}_3^{2-}$  which are not shown. Gray spheres represent  $\text{Ca}^{2+}$  ions and unshaded spheres represent  $\text{CO}_3^{2-}$  ions.



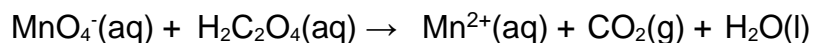
If solution (1) is a saturated solution of  $\text{CaCO}_3$ , which of solutions (1)-(4) represents the solution after a small amount of  $\text{HNO}_3$  is added and equilibrium is restored?

- A. (1)
- B. (2)
- C. (3)
- D. (4)

67. What species is the oxidizing agent in the following redox reaction?

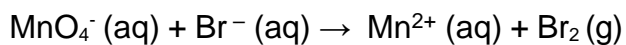


68. Balance the oxidation-reduction reaction in acidic solution. What is the sum of the coefficients?

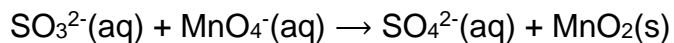


## Recitation Worksheet 12 – Exam 4 Review

69. What is the coefficient of the permanganate ion in the balanced equation between bromide and permanganate ions in acidic solution?



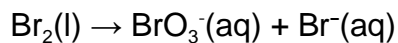
70. Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of  $\text{SO}_3^{2-}$  and  $\text{MnO}_4^-$  in the balanced reaction?



$\text{SO}_3^{2-}$

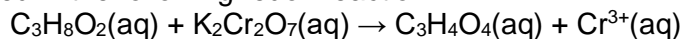
$\text{MnO}_4^-$

71. Balance the following redox reaction if it occurs in basic solution. What is the sum of the coefficients in the balanced reaction?





72. What element is being oxidized in the following redox reaction?




- A. C
- B. H
- C. O
- D. K

73. Which statement is true about redox reactions?

- A. A half-reaction can occur by itself.
- B. A redox reaction in base can include excess  $\text{H}^+$  after it has been balanced.
- C. Two oxidations can occur instead of one oxidation and one reduction.
- D. At least 2 atoms must have their oxidation states change during a redox reaction.
- E. None of these statements are true.

74. A homeowner in Boston becomes concerned that there may be appreciable amounts of lead in her drinking water due to 150-year old water pipes in her house. Consequently, she takes a sample of her drinking water in to be analyzed. The laboratory technician, who is new on the job, has been told to analyze by precipitating the lead ion out as lead iodide ( $K_{\text{sp}} = 7.1 \times 10^{-9}$  for  $\text{PbI}_2(\text{s})$ ) by slowly adding small portions of 1.00 M  $\text{NaI}(\text{aq})$  solution.

If we assume that the concentration of lead in the solution is 1.00 mg/liter or approximately  $4.8 \times 10^{-6}$  M (this would be 1.0 part per million) is it possible to detect the lead in the drinking water by adding a total of no more than 10.0 mL of  $\text{NaI}(\text{aq})$  solution to a 100 mL sample of drinking water? What is  $Q_{\text{sp}}$ ?

## Recitation Worksheet 12 – Exam 4 Review

75. When 100 mL each of  $2.0 \times 10^{-6}$  M  $\text{Ag}^+(\text{aq})$  and  $2.0 \times 10^{-3}$  M  $\text{Br}^-(\text{aq})$  are mixed, what is the remaining  $\text{Ag}^+(\text{aq})$  ion concentration in the solution and is precipitation complete? The solubility product constant of  $\text{AgBr}(\text{s})$  is  $5.0 \times 10^{-13}$ .

- A.  $7.1 \times 10^{-7}$  M, no
- B.  $5.0 \times 10^{-10}$  M, yes
- C.  $1.0 \times 10^{-3}$  M, no
- D.  $5.0 \times 10^{-13}$  M, yes
- E.  $2.5 \times 10^{-10}$  M, yes

76. The solubility product constant of calcium chlorate ( $\text{Ca}(\text{ClO}_3)_2$ ) of water is  $7.1 \times 10^{-7}$  at 25 °C. How many grams of  $\text{Ca}(\text{ClO}_3)_2$  is dissolved in 750 mL of saturated solution?

77. Concentrated aqueous solutions of copper (I) nitrate, sodium sulfate and silver acetate are mixed together. The precipitate which forms is \_\_\_\_\_.

- A. copper (I) acetate
- B. silver nitrate
- C. silver sulfate
- D. sodium acetate
- E. nothing precipitates