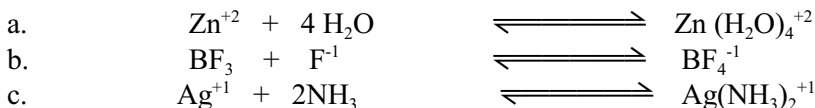
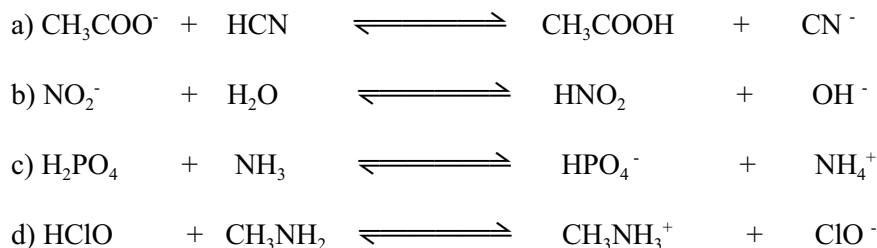


ACID BASE REVIEW

1. Identify Lewis Acid, in the following reactions:



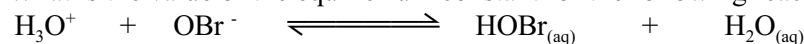
2. Identify the acid – base conjugate pairs in each of the following reactions according with the Bronsted – Lowry framework:



3. The ionization constant for hypobromous acid, HOBr is:



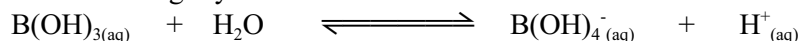
What is the value of the equilibrium constant for the following reaction?



(Answer: $5.0 * 10^8$)

4. Given the K_a for HOCN is $3.3 * 10^{-4}$. What is K_b for OCN⁻?

5. Boric acid, H_3BO_3 , is commonly used in eyewash solution in chemistry laboratories to neutralize bases splashed in the eye. It acts as a monoprotic acid, but the dissociation reaction is slightly different from other acids:



Calculate the pH of a 0.50 mol dm^{-3} solution of boric acid. The K_a for the boric acid is $5.8 * 10^{-10}$.

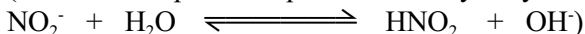
6. What is the pH of a solution that is 0.10 mol dm^{-3} KNO_2 and 0.15 mol dm^{-3} HNO_2 (nitrous acid)?

7. Use Le Chatelier's Principle to predict the effect of the following changes on the extent of the hydrolysis of the $NaNO_2$ (sodium nitrite) solution, upon the addition of:

- a) HCl b) NaOH c) NaCl d) the solution is diluted

Explain each answer.

(Recall the important equation is the hydrolysis of the nitrite ion, NO_2^{-} .)



8. Calculate:

- a) pH of a 0.2 mol dm^{-3} $NaHSO_3$ (K_a for $HSO_3^{-} = 6.2 * 10^{-8}$).
 b) pH of a 0.2 mol dm^{-3} phenoxide ion, $C_6H_5O^{-}$, a weak base ($K_b = 7.7 * 10^{-5}$)
 c) pH of a 0.2 mol dm^{-3} NH_4Cl ? (K_b (NH_3) = $1.8 * 10^{-5}$)
 d) pH of a 0.2 mol dm^{-3} KCN (K_a (HCN) = $4.9 * 10^{-10}$)

9. Which of the following would form a:
- (1) Neutral Solution (2) Acidic Solution (3) Basic Solution
- i) NaH_2PO_4 ii) Na_3PO_4 iii) KCl iv) FeCl_3 v) KCN

10. Calculate the pH of a buffer solution that contains:
- a) 0.25 mol dm^{-3} benzoic acid ($\text{C}_6\text{H}_5\text{COOH}$) and 0.15 mol dm^{-3} sodium benzoate ($\text{C}_6\text{H}_5\text{COONa}$) given ($K_a = 6.5 \times 10^{-10}$).

- b) 500 cm^3 of 0.10 mol dm^{-3} NaOCl and 500 cm^3 of 0.20 mol dm^{-3} HOCl , what is the pH of the solution? ($K_a(\text{HOCl}) = 3.2 \times 10^{-8}$)
- (Answer: 7.19)**

11. You are asked to go into the laboratory and prepare an ethanoic acid – sodium ethanoate buffer solution, with a pH of 4.00 ± 0.02 . What mole ratio of CH_3COOH to CH_3COONa should be used ($K_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$)
- (Answer = 5.50)**

12. Over what range of pH is a $\text{HOCl} - \text{NaOCl}$ buffer effective? ($K_a(\text{HOCl}) = 3.2 \times 10^{-8}$)
- (Answer: 6.5 - 8.5)**

13. Assuming equal concentrations of conjugate base to acid, which one of the following mixture is suitable for making a buffer solution with an optimum pH of 4.6 – 4.8.

- a) $\text{CH}_3\text{COOH} / \text{CH}_3\text{COONa}$ $K_a = 1.8 \times 10^{-5}$
- b) $\text{NH}_3 / \text{NH}_4\text{Cl}$ $K_a = 5.6 \times 10^{-10}$
- c) $\text{NaOCl} / \text{HOCl}$ $K_a = 3.2 \times 10^{-8}$
- d) $\text{NaNO}_2 / \text{HNO}_2$ $K_a = 4.5 \times 10^{-4}$

14. Consider the carboxylic acids, (acids that contain the general formula $-\text{COOH}$ group): ethanoic acid, (CH_3COOH) and chloroethanoic acid, (CH_2ClCOOH). From the equation: $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
- We see that the contributions to the (ΔG°) term are the enthalpy term (ΔH°) and a temperature time entropy term ($T\Delta S^\circ$). These contributions are listed below for the two acids at 298 K.

Acid	ΔH° (mol dm^{-3})	$T\Delta S^\circ$ (mol dm^{-3})
CH_3COOH	- 0.57	27.6
CH_2ClCOOH	- 4.7	21.1

- a) Calculate ΔG° for the ionization of these two acids at 25°C .
- b) Calculate the acid ionization constant, K_a of chloroethanoic acid at 25°C . Recall: $\Delta G^\circ = -RT \ln K$
- c) Which is the dominant term (ΔH° or $T\Delta S^\circ$) in determining the value of ΔG° , (and hence K_a) of the acid?
- d) What processes contribute to the ΔH° in the ionization of these acids? (Consider the ionization of the acid as a Bronsted-Lowry acid – base reaction; ie, what bonds need to be broken and what bonds need to be formed.)

15. 50.0 cm^3 of 0.10 mol dm^{-3} nitrous acid, HNO_2 , was titrated with of 0.10 mol dm^{-3} KOH solution. After 25.0 cm^3 KOH solution, what will be the pH in the titration flask? ($K_a = 4.50 \times 10^{-4}$)
- (Answer: 2.41)**

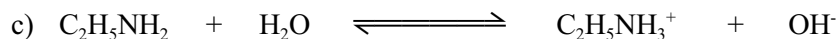
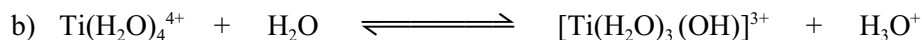
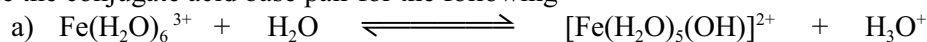
16. Calculate the pH at the equivalence point for the titration of 20.0 cm³ of 0.20 mol dm⁻³ HCl with 30.0 cm³ of 0.20 mol dm⁻³ NH₃ ($K_b = 1.82 \times 10^{-5}$)
17. Rank the following 0.01 mol dm⁻³ solutions of the following three acids from the highest to the lowest in acid strength. Explain your reasoning:
 A. CH₃COOH B. CH₂ClCOOH C. CCl₃COOH
18. In the reaction: $C_6H_5COOH + F^- \rightleftharpoons C_6H_5COO^- + HF$
 $K_a(C_6H_5COOH) = 6.50 \times 10^{-5}$, $K_a(HF) = 3.50 \times 10^{-4}$
 Explain if the products or the reactants will be favoured at equilibrium.
19. Which statements is true about solutions with pH of 2.0 and 4.0.
 a) The [H⁺] when pH = 2.0 is the 100 times that when pH = 4.0.
 b) The [H⁺] when pH = 4.0 is the 100 times that when pH = 2.0.
 c) The [H⁺] when pH = 4.0 is the twice that when pH = 2.0.
 d) The [H⁺] when pH = 2.0 is the twice that when pH = 4.0.
19. An aqueous solution of a weak monoprotic acid ($K_a = 1.0 \times 10^{-5}$) exhibits a pH = 3. What is the concentration of the acid.
 (a) 0.1M (b) 0.01M (c) 0.001M (d) 1×10^{-6} M
20. Which one of the following species can function both as an acid and a base under the Bronsted-Lowry definition:
 a) HS⁻ b) S²⁻ c) NH₄⁺ d) Al³⁺
21. The pK_a values of ethanoic acid CH₃COOH and trichloroethanoic acid, CH₂ClCOOH, are 5.0 and 1.0 respectively. What is the value of the ratio of the dissociation constants (trichloroethanoic acid / ethanoic acid)
 a) 0.2 b) 5 c) 5000 d) 10000

QUIZ: ACID - BASE

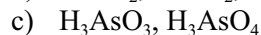
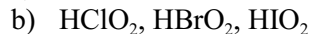
- 1) Which of HNO_3 or HNO_2 is a stronger acid. Explain.
- 2) Why is HOBr as weaker acid than HOCl ?
- 3) Which is the stronger base: F^- or Cl^- ? How do you know?
- 4) Calculate the pH of an aqueous solution of 0.55 mol dm^{-3} formic acid HCOOH and 0.63 mol dm^{-3} sodium formate HCOONa . The pK_a for formic acid is 3.14.
- 5) At normal body temperature 37°C , K_w has a the value 2.38×10^{-14} . Calculate the pH of a neutral aqueous solution in the body.
(Answer: pH = 6.81)
- 6) The $[\text{OH}^-]$ in a 0.0250 solution of HI at 25°C is:
 - a) $2.5 \times 10^{-12} \text{ M}$
 - b) $4.00 \times 10^{-12} \text{ M}$
 - c) $2.50 \times 10^{-2} \text{ M}$
 - d) $1.60 \times 10^{-2} \text{ M}$
- 7) The pH of an aqueous solution is 3.52. The $[\text{H}^+]$ is:
 - a) 5.2×10^{-3}
 - b) 3.0×10^3
 - c) 4.7×10^{-4}
 - d) 3.0×10^{-4}
- 4) The acid ionization constant K_a for $\text{HSO}_3^- = 6.2 \times 10^{-8}$. The base ionization constant, K_b for SO_3^{2-} is:
 - a) 1.7×10^{-2}
 - b) 2.50×10^{-4}
 - c) 3.12×10^{-8}
 - d) 1.60×10^{-7}
- 5) Formic acid HCOOH , a monoprotic acid was formerly obtained by distillation of red ants. At 25°C , K_a for $\text{HCOOH} = 1.7 \times 10^{-4}$. For a 2.32 solution HCOOH , calculate:
 - a) pH of solution
 - b) % Ionization of the solution.
- 6) Calculate the $[\text{H}^+]$ of a 0.10 mol dm^{-3} solution of a weak base pyridinium chloride, $\text{C}_5\text{H}_5\text{NHCl}$. The K_b for pyridine ($\text{C}_5\text{H}_5\text{N}$) = 3.12×10^{-6} .

REVIEW QUESTIONS: ACID – BASE TEST

1) Write the conjugate acid base pair for the following



2) Place the following in increasing acid strength:



3) What are the hydronium ion and hydroxide ion concentrations in a $0.050 \text{ mol dm}^{-3}$ aqueous solution of hydrogen chloride.

4) a) What will be the pH of an aqueous solution containing $0.040 \text{ mol dm}^{-3}$ NaOH?

b) 0.10 mol dm^{-3} solution of barium hydroxide.

c) $0.033 \text{ mol dm}^{-3}$ solution of calcium hydroxide, $\text{Ca}(\text{OH})_2$

5) What is the hydronium ion concentration of a solution with a pH of 2.50.

6) If the hydronium ion concentration $[\text{H}_3\text{O}^+] = 1.44 \times 10^{-3} \text{ mol dm}^{-3}$, what is the pOH?

7) If the pOH = 7.41 what is the $[\text{H}_3\text{O}^+]$?

8) If the pH = 0.34, what is the $[\text{OH}^-]$?

9) If the pOH = 5.52, what is the $[\text{H}^+]$?

10) Acetylsalicylic acid, (aspirin), is a weak monoprotic acid which can be abbreviated as Hasp. A 0.10 mol dm^{-3} solution of the acid has a pH of 2.24. Calculate the acid ionization concentration constant, K_a for acetylsalicylic acid.

11) Ascorbic acid, (Vitamin C), is a weak monoprotic acid which can be abbreviated as HAsc. It has an ionization constant of 8.0×10^{-3} , calculate the pH of a $0.100 \text{ mol dm}^{-3}$ solution.

12) A new drug obtained from seeds of a strange Colombian plant was found to be a weak organic base. A $0.100 \text{ mol dm}^{-3}$ solution in H_2O of this drug has a pH of 10.8. What is the K_b of the drug?

13) Caffeine is a weak base that is related to NH_3 . For the purposes of this example we can abbreviate its formula to CafN. It has a base ionization constant of 4.4×10^{-4} . Calculate the pH of a 0.70 mol dm^{-3} solution.

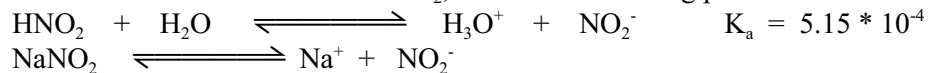
14) What is the pH of 0.22 mol dm^{-3} solution of formic, HCOOH , which has a $\text{p}K_a = 3.42$.

15) What is the pH of a weak base, diethyl amine $(\text{C}_2\text{H}_5)_2\text{NH}$, $0.226 \text{ mol dm}^{-3}$ solution has a $\text{p}K_a = 2.62$.

16) A 0.32 mol dm^{-3} solution of chlorous acid, HClO_2 has a K_a of 1.22×10^{-4} . What is the percent ionization of HClO_2 .

17) When 0.0250 mol $\text{NaNO}_{2(s)}$ is added to :

a) 500 cm^3 solution of 0.100 mol dm^{-3} HNO_2 , what is the resulting pH?



18) What is the:

a) pH a 1.0 mol dm^{-3} solution.

b) pH in NH_3 and 0.10 mol dm^{-3} in NH_4NO_3

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

19) What is the pH of a solution, what is the % ionization of 0.10 mol dm^{-3} HF in

a) H_2O

b) In the presences of 1.0 mol dm^{-3} aqueous solution of NaF.

$$K_a(\text{HF}) = 7.22 \times 10^{-2}$$

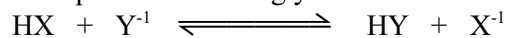
20) Calculate the $[\text{OH}^-]$, pH, % ionization of a solution of 0.10 mol dm^{-3} NH_3 $K_b=1.8 \times 10^{-5}$.

21) Calculate the hydrogen ion concentration, and the pH of a 0.220 mol dm^{-3} solution of vitamin C, (ascorbic acid), with a $K_a = 7.95 \times 10^{-5}$ at 25 $^\circ\text{C}$.

22) A solution of hydrofluoric acid contains 2.00 g of HF per dm^3 and has a pH of 2.22.

What is the acid ionization constant for HF?

23) The formation of products is strongly favoured in this acid-base system:



a) Identify the bases competing for protons.

b) Which base is stronger?

c) Which is the weaker acid HX or HY?

d) Does the K_a for this system have a large or small value?

e) How is the equilibrium affected by the addition of the soluble salt NaY?

TEST: ACID BASE

1) Lactic acid (2-hydroxypropanoic acid), $C_6H_{12}O_3$, is a weak monoprotic acid. It is found in sour milk and in the blood after vigorous exercise.

- Write the equilibrium expression for the dissociation of this acid and calculate the $[H_3O^+]$ for 0.12 mol dm^{-3} solution of lactic acid. (K_a (lactic acid) =)
- Find the %ionization of a 0.12 mol dm^{-3} solution of lactic acid.
- Koumiss, a fermented beverage made from mare's milk contains 12.2 g of lactic acid in 25 cm^3 of water. Calculate the volume of 0.15 mol dm^{-3} NaOH that would be needed to neutralise the lactic acid.

2)

- The value of the pK of propanoic acid, C_2H_5COOH , is 4.87. What is the value of K_a ?
- Calculate the pH of a $0.240 \text{ mol dm}^{-3}$ aqueous solution of propanoic acid.
- 9.60g of C_2H_5COONa is dissolved in 150 cm^3 of 0.24 mol dm^{-3} propanoic acid. What will be the resulting pH of the solution. State any approximation you have made in obtaining the answer.

[Note: $MM(C_2H_5COONa) = 96 \text{ g mol}^{-1}$, $\therefore n = 0.100 \text{ mol}$, $\therefore c = n/V = 0.10/0.15 = 0.667 \text{ mol dm}^{-3}$]

- Explain how the solution in (c) can act as a buffer solution if small amounts of acid or alkali are added.

3) A 0.10 mol dm^{-3} solution of which of the following acids will have the greater $[H^+]$?

- | | |
|---------------|------------------------|
| a) HNO_2 | $K_a = 1.3 * 10^{-4}$ |
| b) H_2SO_3 | $K_a = 1.3 * 10^{-2}$ |
| c) H_3PO_4 | $K_a = 7.7 * 10^{-3}$ |
| d) H_2SiO_3 | $K_a = 1.7 * 10^{-10}$ |

4) Only one of the following substances CANNOT function as a Lewis acid or Lewis base. Identify that substance on the basis of its structure.

- a) NH_4^+ b) NH_2^- c) NH_3 d) BF_3 e) OH^-

5) A student determined the concentration of a solution of hydrochloric acid by an acid-base titration. When a 45.0 cm^3 sample of the acid was titrated to a phenolphthalein endpoint, 36.0 cm^3 of 0.15 mol dm^{-3} KOH was required. What was the molarity of the HCl solution?

- a) 0.30 b) 0.24 c) 0.12 d) 0.06

6) A solution is prepared by adding 0.25 mol of CH_3COOH of solution. The pH of this solution is 2.67 and the % ionization 0.848 %. What will happen to the pH and the % ionization of this solution as it is diluted with H_2O to a volume of 2.0 dm^3 .

- The pH will increase, the % ionization it increase.
- The pH will decrease, the % ionization it increase.
- The pH will increase, the % ionization it decrease.
- The pH will decrease, the % ionization it decrease.

7) Which of the following solutes at a concentration of 0.1M will produce an acidic solution?

- I) NH_4Cl II) CH_3COONa III) $Fe_2(SO_4)_3$

- I only
- II only
- I and II only
- I, II, III