Acid/Base - Aquesous Equilibria Review

1. The conjugate base of H2PO4– is

(A) H3PO4 (B) NaH2PO4 (C) PO43– (D) HPO42–

2. HCl is a strong acid. What is the pH of 200 mL of 0.002 M HCl?

(A) 2.0 (B) 2.7 (C) 3.4 (D) 4.0

3. In which pair is the first member a stronger proton–donating acid than the second member?

(A) HClO4, HClO3 (C) H2SO3, H2SO4

(B) HIO, HBrO (D) H2O, H2S

4. In which pair of acids is the first member stronger than the second?

(A) HClO > HIO (C) H3PO4 > HNO3

(B) H2SO3 > H2SO4 (D) HBrO > HBrO2

5. An element reacts with dilute HCl, forms an amphoteric hydroxide, and is commonly found in the +2 oxidation state. The element is probably

(A) Zn (B) Na (C) Al (D) Cu

6. A water solution of which salt is acid to litmus paper?

(A) NaCl (B) KC2H3O2 (C) NH4Cl (D) Na2CO3 (E) KNO3

7. Which equation best represents the net reaction that occurs when sodium hydroxide and hydrochloric acid solutions are mixed?

(A) Na+ + HCl NaCl + H+ (B) OH– + HCl H2O + Cl–

(C) OH– + H3O+ 2H2O (D) NaOH + H3O+ 2H2O + Na+

8. Which are the elements whose oxides form acids when placed in water?

(A) those found in the lower–left portion of the periodic table

(B) the alkali metals

(C) the rare earth elements

(D) those found in the upper–right portion of the periodic table

(E) amphoteric elements

9. Which is the strongest Brønsted base?

(A) HOH (B) OH– (C) Cl– (D) O2–

10. Which species can act either as an acid or as a base in aqueous solution?

(A) HCO3– (B) HNO2 (C) HIO4 (D) H3PO4

11. Which species can act either as an acid or as a base in aqueous solution?

(A) OH- (B) NO2- (C) HIO4 (D) H2PO4 -1

12. Which particles are present in the greatest number in a dilute sulfuric acid solution?

1. H2SO4 molecules (B) HSO4– ions (C) SO42– ions (D) H3O+ ions (E) OH– ions

13. Which forms the strongest acid in the +5 oxidation state?

(A) nitrogen (D) antimony

(B) phosphorus (E) bismuth

(C) arsenic

14. Which 0.1 M solution has a pH of approximately 9?

(A) NaHCO3 (D) Na2SO4

(B) NaOH (E) Al2(SO4)3

(C) HCl

15. The pH of a 1.0 10–3 M Ba(OH)2 solution at 25 °C is

(A) 2.7 (B) 3.0 (C) 11.0 (D) 11.3

16. In titrating NH3*(aq)* with 0.1 M HCl, the equivalence point in pH units will be

(A) lower than 7 due to hydrolysis of NH4+

(B) lower than 7 due to hydrolysis of Cl–

(C) higher than 7 due to hydrolysis of NH4+

1. higher than 7 due to hydrolysis of Cl–

17. Which statement is a logical inference from the fact that a 0.10 M solution of potassium acetate, KC2H3O2, is less alkaline than a 0.10 M solution of potassium cyanide, KCN?

(A) Hydrocyanic acid is a weaker acid than acetic acid.

(B) Hydrocyanic acid is less soluble in water than acetic acid.

(C) Cyanides are less soluble than acetates.

(D) Acetic acid is a weaker acid than hydrocyanic acid

18. Which is the weakest halogen acid?

(A) HF (B) HCl (C) HBr (D) HI

19. Which pair constitutes a buffer in aqueous solution?

(A) HCl and NaCl (C) HBr and KBr

(B) NH3 and NH4Cl (D) HNO3 and NH4NO3

20. In the titration of 50.0 mL of 0.100 M benzoic acid (a monoprotic acid) with 50.0 mL of 0.100 M Na0H, the properties of the solution at the equivalence point will correspond exactly to the properties of

(A) a 0.100 M sodium solution. (B) a 0.0500 M sodium hydroxide solution.

(C) a 0.0500 M benzoic acid solution. (D) a 0.0500 M sodium benzoate solution.

21. When equal volumes of 0.1 M solutions of HCl and NaOH are mixed, the ***total number*** of ions present will be approximately

(A) twice as great as before mixing. (B) the same as before mixing.

(C) half as great as before mixing. (D) 10–7 times as great as before mixing.

(E) 10–14 times as great as before mixing.

22. Which substance forms ***two*** acids when placed in contact with water?

(A) HCl (B) HBr (C) Cl2 (D) Na

23. A 0.10 M C6H5COOH solution has a pH of 2.59. What is the *K*a of this acid?

(A) 6.6 10–6 (B) 6.6 10–5 (C) 2.6 10–3 (D) 2.6 10–2

Use for questions 24-26



24. A volume of 10.0 mL of 0.10 M H3PO4 was titrated with 0.10 M NaOH. The pH response to addition of various amounts of NaOH is shown. At point **A** the ratio of [H3PO4]/[H2PO4–] is

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

25. At point **C** the principal phosphate species present are

(A) H3PO4 and HPO42– (B) PO43– and HPO42–

(C) HPO42– and H2PO4– (D) H2PO4– and H3PO4

26. The end–point for the reaction H3PO4 + NaOH  NaH2PO4 + H2O is the point labeled

(A) **A** (B) **B** (C) **C** (D) **D**

27. The *weakest* of the bases listed is

*K*a (Ionization

Acid Conjugate Base Constant of Acid)

HCl Cl– 100% ionized

HSO4– SO42– 1.2 10–2

H2S HS– 5.7 10–8

HS– S2– 1.2 10–13

(A) Cl– (B) CN– (C) HS– (D) S2– (E) SO42–

1972

A 5.00 gram sample of a dry mixture of potassium hydroxide, potassium carbonate, and potassium chloride is reacted with 0.100 liter of 2.00 molar HCl solution

(a) A 249 milliliter sample of dry CO2 gas, measured at 22\_C and 740 torr, is obtained from this reaction. What is the percentage of potassium carbonate in the mixture?

(b) The excess HCl is found by titration to be chemically equivalent to 86.6 milliliters of 1.50 molar NaOH. Calculate the percentages of potassium hydroxide and of potassium chloride in the original mixture.

1990 D

Give a brief explanation for each of the following.

(a) For the diprotic acid H2S, the first dissociation constant is larger than the second

dissociation constant by about 105 (K1 \_ 105 K2).

(b) In water, NaOH is a base but HOCl is an acid.

1. HCl and HI are equally strong acids in water but, in pure acetic acid, HI is a

stronger acid than HCl.

(d) When each is dissolved in water, HCl is a much stronger acid than HF.

Phlegmic acid has a Ka of 1.88 x 10-6.

1. Calculate the pH of a 0.67M solution.
2. What is the percent dissociation ?
3. What is the pH of a 0.36M solution of sodium Phegmate?
4. If 10.0 mL of phlegmic acid spilled on the bench top, what would you do?

1978 A

A 0.682 gram sample of an unknown weak monoprotic organic acid, HA was dissolved in sufficient water to make 50 milliliters of solution and was titrated with a 0.135 molar NaOH solution. After the addition of 10.6 milliliters of base, a pH of 5.65 was recorded. The equivalence point (end point) was reached after the addition of 27.4 milliliters of the 0.135 molar NaOH.

(a) Calculate the number of moles of acid in the original sample.

(b) Calculate the molecular weight of the acid HA.

(c) Calculate the number of moles of unreacted HA remaining in solution when the pH was 5.65.

(d) Calculate the [H3O+] at pH = 5.65

(e) Calculate the value of the ionization constant, Ka, of the acid HA.

1987 A

NH3 + H2O <=> NH4+ + OH- Ammonia is a weak base that dissociates in water as shown above. At 25ºC, the base dissociation constant, Kb, for NH3 is 1.8x10-5.

(a) Determine the hydroxide ion concentration and the percentage dissociation of a 0.150 molar solution of ammonia at 25ºC.

(b) Determine the pH of a solution prepared by adding 0.0500 mole of solid ammonium chloride to 100. millilitres of a 0.150 molar solution of ammonia.

(c) If 0.0800 mole of solid magnesium chloride, MgCl2, is dissolved in the solution prepared in part (b) and the resulting solution is well-stirred, will a precipitate of Mg(OH)2 form? Show calculations to support your answer. (Assume the volume of the solution is unchanged. The solubility product constant for Mg(OH)2 is 1.5x10-11.

1988 D



A 30.00 millilitre sample of a weak monoprotic acid was titrated with a standardized solution of NaOH. A pH meter was used to measure the pH after each increment of NaOH was added, and the curve above was constructed.

(a) Explain how this curve could be used to determine the molarity of the acid.

(b) Explain how this curve could be used to determine the dissociation constant Ka of the weak monoprotic acid.

(c) If you were to repeat the titration using a indicator in the acid to signal the endpoint, which of the following indicators should you select? Give the reason for your choice.

Methyl red Ka = 1x10-5

Cresol red Ka = 1x10-8

Alizarin yellow Ka = 1x10-11

(d) Sketch the titration curve that would result if the weak monoprotic acid were replaced by a strong monoprotic acid, such as HCl of the same molarity. Identify differences between this titration curve and the curve shown above.

1993 A

CH3NH2 + H2O <=> CH3NH3+ + OH-

Methylamine, CH3NH2, is a weak base that reacts according to the equation above. The value of the ionization constant, Kb, is 5.25x10-4. Methylamine forms salts such as methylammonium nitrate, (CH3NH3+)(NO3-).

(a) Calculate the hydroxide ion concentration, [OH-], of a 0.225-molar aqueous solution of methylamine.

(b) Calculate the pH of a solution made by adding 0.0100 mole of solid methylammonium nitrate to 120.0 milliliters of a 0.225-molar solution of methylamine. Assume no volume change occurs.

(c) How many moles of either NaOH or HCl (state clearly which you choose) should be added to the solution in (b) to produce a solution that has a pH of 11.00? Assume that no volume change occurs.

(d) A volume of 100. milliliters of distilled water is added to the solution in (c). How is the pH of the solution affected? Explain.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 D | 2 B | 3 A | 4 A | 5 D | 6 C | 7 C | 8 D | 9 D | 10 A |
| 11 D | 12 D | 13 A | 14 A | 15 D | 16 A | 17 A | 18 A | 19 B | 20 D |
| 21 C | 22 C | 23 B | 24 A | 25 C | 26 B | 27 A |  |  |  |

1978 Answer:

(a) at equivalence point, moles HA = moles NaOH

= MbVb = (0.0274 L)(0.135 M) = 3.70x10-3 mol HA

(b) 

(c) HA + OH- --> A- + H2O

initial: 0.00370 mol

added: (0.0106L)(0.135M) = 0.00143 mole

remaining: (0.00370 - 0.00143) = 0.00227 mol

(d) pH = -log[H3O+]; [H3O+] = 10-pH = 10-5.65

= 2.2x10-6M

(e)  = 1.4x10-6

1972 answer

(a) K2CO3 + 2 HCl →CO2 + 2 KCl + H2O



= 0.0100 mol CO2





(b)original mol HCl = 0.100 L x 2.00M= 0.200 mol

reacted with K2CO3= 0.020 mol

excess HCl = 0.0866L x 1.50M= 0.130 mol

mol HCl that reacted w/KOH= 0.050 mol

0.050 mol KOH = 2.81 g = 56.1% of sample

the remaining KCl amounts to 16.3%

**1990Answer:**

(a) After the first H+ is lost from H2S, the remaining species, HS–, has a negative charge. This increases the attraction of the S atom for the bonding electrons in HS–. Therefore, the bond is stronger, H+ is harder to remove, and K2 is lower.

(b) Polar H2O can separate ionic NaOH into Na+*(aq)* and OH–*(aq)*, giving a basic solution. In HOCl, chlorine has a high attraction for electrons due to its greater charge density. This draws electrons in the H–O bond towards it and weakens the bond. H+ can be removed, making an acid solution.

(c) Water is a more basic solvent (greater attraction for H+) and removes H+ from HCl and HI equally.

Acetic acid has little attraction for H+, but the H+ separates from the larger I– more easily than from the smaller Cl–.

(d) The bond between H and Cl is weaker than the bond between H and F. Therefore, HCl is a stronger acid.

1987a Answer:

(a) [NH4+] = [OH-] = X; [NH3] = (0.150 - X)

 ; 1.8x10-5 = 

X= [OH-] = 1.6x10-3 M

% diss. =  x 100% = 1.1%

(b) [NH4+] = 0.0500 mol/0.100L = 0.500M

[NH3] = 0.150M



pOH = 5.27; pH = (14 - 5.27) = 8.73

(c) Mg(OH)2 <=> Mg2+ + 2 OH-

[Mg2+] = (0.0800mol/0.100L) = 0.800M

[OH-] = 5.4x10-6M

*Q* = [Mg2+][OH-]2 = (0.800)(5.4x10-6)2

= 2.3x10-11

*Q* > Ksp so Mg(OH)2 precipitates

1988d Answer:

(a) The sharp vertical rise in pH on the pH-volume curve appears at the equivalence point (about 23 mL). Because the acid is monoprotic, the number of moles of acid equals the number of moles of NaOH. That number is the product of the exact volume and the molarity of the NaOH. The molarity of the acid is the number of moles of the acid divided by 0.30L, the volume of the acid.

(b) At the half-equivalence point (where the volume of the base added is exactly half its volume at the equivalence point), the concentration [HX] of the weak acid equals the concentration [X-] of its anion. Thus, in the equilibrium expression [H+][X-]/[HX] = Ka, [H+] = Ka. Therefore, pH at the half-equivalence point equals pKa.

(c) Cresol red is the best indicator because its pKa (about 8) appears midway in the steep equivalence region. This insures that at the equivalence point the maximum color change for the minimal change in the volume of NaOH added is observed.

1993

(a) 

CH3NH2 + H2O <=> CH3NH3+ + OH-

I 0.225 0 0

C -X +X +X

E 0.225-X X X



X = [OH-] = 1.09x10-2 M

solved using quadratic: X = [OH-] = 1.06x10-2 M

(b) [CH3NH3+] = 0.0100 mol / 0.1200 L = 0.0833 M

or CH3NH2 = 0.120 L x 0.225 mol/L = 0.0270 mol



X = [OH-] = 1.42x10-3 M; pOH = 2.85; pH = 11.15

OR



OR



(c) HCl must be added.



X = 0.0228 M

0.0228 mol/L x 0.120 L = 2.74x10-3 mol HCl

OR



0.0227 M x 0.120 L = 2.73x10-3 mol HCl

(d) The  ratio does not change in this buffer solution with dilution, therefore, no effect on pH.\