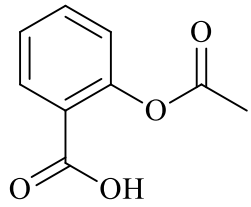
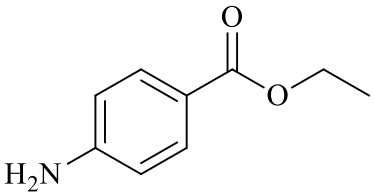
Marks 5

- The structures of the drugs aspirin and benzocaine are shown below.

  (a) Draw the conjugate base of aspirin and the conjugate acid of benzocaine.
  (b) *Circle* the form of each that will be present in a highly acidic environment.

 aspirin	conjugate base of aspirin
 benzocaine	conjugate acid of benzocaine

Ions are less likely to cross cell membranes than uncharged molecules. One of the drugs above is absorbed in the acid environment of the stomach and the other is absorbed in the basic environment of the intestine. Identify which is absorbed in each environment below and *briefly* explain your answers.

Drug absorbed in the stomach:	aspirin / benzocaine
Drug absorbed in the intestine:	aspirin / benzocaine

Aspirin, $C_9H_8O_4$ is not very soluble in water. "Soluble aspirin", the sodium salt $NaC_9H_7O_4$, is often administered instead. Is a solution of "soluble aspirin" acidic or basic? Briefly explain your answer.

THIS QUESTION CONTINUES ON THE NEXT PAGE.

Marks 7

Calculate the pH of a 0.010 M solution of aspirin at 25 °C. The pK_a of aspirin is 3.5 at this temperature.

pH =

Ammonia, NH_3, is a weak base in water. Write the equation for the acid/base reaction between aspirin and ammonia.

What is the expression for the equilibrium constant, K, for this reaction?

Rewrite this expression in terms of the K_a of aspirin and the K_a of NH_4^+. (Hint: multiply by $[H^+]/[H^+] = 1$) Hence calculate the value of K. The pK_a of NH_4^+ is 9.2.

Answer:

Would aspirin dissolve in a solution of ammonia? Explain your answer.

Marks 6

- Solution A consists of a 0.050 M aqueous solution of benzoic acid, C_6H_5COOH, at 25 °C. Calculate the pH of Solution A. The pK_a of benzoic acid is 4.20.

pH =

Other than water, what are the major species present in solution A?

Solution B consists of a 0.050 M aqueous solution of ammonia, NH_3, at 25 °C. Calculate the pH of Solution B. The pK_a of NH_4^+ is 9.24.

pH =

Other than water, what are the major species present in solution B?

THIS QUESTION CONTINUES ON THE NEXT PAGE.

Marks
5

Write the equation for the reaction that occurs when benzoic acid reacts with ammonia?

Write the expression for the equilibrium constant for the reaction of benzoic acid with ammonia?

What is the value of the equilibrium constant for the reaction of benzoic acid with ammonia?

Answer:

What are the major species in the solution that results from dissolving equimolar amounts of benzoic acid and ammonia in water?

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

	Marks
• What is the pH of a 0.1 M solution of ammonium chloride, given the K_b for ammonia is 1.8×10^{-5}.	**4**

pH =

What is the ratio of ammonia to ammonium ion in this solution?

Answer:

• What is the pH of a solution which is 0.10 M in both acetic acid and sodium acetate? The K_a for acetic acid is 1.8×10^{-5}.	**Marks 4**
Answer:	

What is the final pH if 0.010 mol of HCl is added to 1.0 L of the above solution?

Answer:	

Marks 7

- The pK_a of formic acid, HCO_2H, is 3.77. What is the pH of a 0.20 M solution of formic acid?

pH =

Give the equation for the reaction of formic acid with solid sodium hydroxide.

Calculate the ratio of formate ion / formic acid required to give a buffer of pH 4.00.

Answer:

What amount (in mol) of sodium hydroxide must be added to 100.0 mL of 0.20 M HCO_2H to prepare a solution buffered at pH 4.00?

Answer:

Marks
8

- Solution A consists of a 1.00 M aqueous solution of HOCl at 25 °C. The pK_a of HOCl is 7.54. Calculate the pH of Solution A.

pH =

At 25 °C, 1.00 L of Solution B consists of 74.4 g of NaOCl dissolved in water. Calculate the pH of Solution B.

pH =

Solution B (0.40 L) is poured into Solution A (0.60 L). What amount of NaOH (in mol) must be added to give a solution, after equilibration, with a pH of 8.20?

Answer:

Marks 4

- What is the pH of a 0.100 M solution of sodium acetate?
  The pK_a of acetic acid is 4.76.

pH =

What is the ratio of acetate ion to acetic acid in this solution?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

	Marks
• Citric acid, $C_6H_8O_7$, has three pK_a values: pK_{a1} = 3.13, pK_{a2} = 4.76 and pK_{a3} = 6.40. Explain, giving exact volumes and concentrations, how to make 1.0 L of a citrate-based buffer with pH 5.58.	**4**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks 7

- A 20.0 mL solution of nitrous acid (HNO_2, pK_a = 3.15) was titrated to its equivalence point with 24.8 mL of 0.020 M NaOH. What is the concentration of the HNO_2 solution?

Answer:

What was the pH at the start of the titration?

pH =

What was the pH after (a) 12.4 mL and (b) 24.8 mL of the NaOH had been added?

(a) 12.4 mL: pH =

(b) 24.8 mL: pH =

Qualitatively, how would each of these three pH values be affected if 5 mL of water were added to the 20.00 mL of nitrous acid before beginning the titration?

	Marks
• Explain why HOCl is a stronger Brønsted acid than HOBr but HCl is a weaker acid than HBr.	**2**

Page Total:

Marks 8

- Aqua ligands in coordination complexes are generally acidic. Briefly explain this phenomenon using $[Co(NH_3)_5(OH_2)]^{3+}$ as an example.

Solution A consists of a 0.10 M aqueous solution of $[Co(NH_3)_5(OH_2)](NO_3)_3$ at 25 °C. Calculate the pH of Solution A. The pK_a of $[Co(NH_3)_5(OH_2)]^{3+}$ = 5.69.

pH =

At 25 °C, 1.00 L of Solution B consists of 28.5 g of $[Co(NH_3)_5(OH)](NO_3)_2$ dissolved in water. Calculate the pH of Solution B.

pH =

Using both Solutions A and B, calculate the volumes (in mL) required to prepare a 1.0 L solution with a pH = 7.00.

Page Total:

Marks 8

- Solution A consists of a 0.020 M aqueous solution of propionic acid, $C_3H_6O_2$, at 25 °C. Calculate the pH of Solution A. The pK_a of propionic acid is 4.87.

Answer:

At 25 °C, 1.00 L of Solution B consists of 2.24 g of potassium propionate ($KC_3H_5O_2$) dissolved in water. Calculate the pH of Solution B.

Answer:

Solution B (1.00 L) is poured into Solution A (1.00 L) and allowed to equilibrate at 25 °C to give Solution C. Calculate the pH of Solution C.

Answer:

If you wanted to adjust the pH of Solution C to be exactly equal to 5.00, which component in the mixture would you need to increase in concentration?

Marks 7

- Solution A consists of a 0.020 M aqueous solution of aspirin (acetylsalicylic acid, $C_9H_8O_4$) at 25 °C. Calculate the pH of Solution A. The pK_a of aspirin is 3.52.

Answer:

At 25 °C, 1.00 L of Solution B consists of 4.04 g of sodium acetylsalicylate ($NaC_9H_7O_4$) dissolved in water. Calculate the pH of Solution B.

Answer:

Solution B (200.0 mL) is mixed with Solution A (400.0 mL) and water (200.0 mL) to give Solution C. Calculate the pH of Solution C after equilibration at 25 °C.

Answer:

If you wanted to adjust the pH of Solution C to be exactly equal to 3.00, which component in the mixture would you need to increase in concentration?

- Calculate the pH of a 0.20 M solution of potassium fluoride. The pK_a of HF is 3.17.

Marks
3

Answer:

- A 300.0 mL solution of HCl has a pH of 1.22. Given that the pK_a of iodic acid, HIO_3, is 0.79, how many moles of sodium iodate, $NaIO_3$, would need to be added to this solution to raise its pH to 2.00?

3

Answer:

Marks 5

- Buffers made of mixtures of $H_2PO_4^-$ and HPO_4^{2-} are used to control the pH of soft drinks. What is the pH of a 350 mL drink containing 6.0 g of NaH_2PO_4 and 4.0 g of Na_2HPO_4?

  For phosphoric acid, H_3PO_4, pK_{a1} = 2.15, pK_{a2} = 7.20 and pK_{a3} = 12.38.

Briefly describe how this buffer system functions. Use equations where appropriate.

Is this buffer better able to resist changes in pH following the addition of acid or of base? Explain your answer.

Marks 8

- Solution A consists of a 0.20 M aqueous solution of formic acid, HCOOH, at 25 °C. Calculate the pH of Solution A. The pK_a of HCOOH is 3.75.

Answer:

At 25 °C, 1.00 L of Solution B consists of 13.6 g of sodium formate, $NaHCO_2$, dissolved in water. Calculate the pH of Solution B.

Answer:

Solution B (1.00 L) is poured into Solution A (1.00 L) and allowed to equilibrate at 25 °C to give Solution C. Calculate the pH of Solution C.

Answer:

If you wanted to adjust the pH of Solution C to be exactly equal to 3.00, which component in the mixture would you need to increase in concentration?

Marks
5

- Often pH is used to characterise acidic solutions. Give a brief definition of pH.

Describe the difference between a strong acid and a weak acid.

In general, can pH be used to define the strength of an acid? Explain your answer.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

4

- Describe the difference between a strong and a weak acid.

Describe in qualitative terms how the percentage ionisation of a weak acid changes when an aqueous solution thereof is diluted.

Which chemical principle can be used to explain the change in percentage ionisation of a weak acid on dilution and how?

Marks 8

- Solution A consists of a 0.25 M aqueous solution of hydrazoic acid, HN_3, at 25 °C. Calculate the pH of Solution A. The pK_a of HN_3 is 4.63.

Answer:

At 25 °C, 1.00 L of Solution B consists of 13.0 g of sodium azide (NaN_3) dissolved in water. Calculate the pH of Solution B.

Answer:

Solution B (1.00 L) is poured into Solution A (1.00 L) and allowed to equilibrate at 25 °C to give Solution C. Calculate the pH of Solution C.

Answer:

If you wanted to adjust the pH of Solution C to be exactly equal to 4.00, which component in the mixture would you need to increase in concentration?

Marks 6

- Calculate the pH a 0.200 M solution of acetic acid, CH_3COOH, at 25 ºC. (The pK_a of acetic acid is 4.76).

pH =

Solid sodium acetate, $NaCH_3CO_2$, (0.15 mol) was dissolved in 0.500 L of 0.200 M acetic acid and the volume made up to 750 mL with water. What is the pH of the resulting solution?

pH =

How much more $NaCH_3CO_2$ needs to be dissolved in the above solution to give a final pH of 5.00?

Answer:

Marks 4

- Regulation of our blood's pH value is of vital importance for our health. In a healthy person the blood pH does not vary by more than 0.2 from the average 7.4. How does our body regulate the pH of blood?

During exercise, CO_2 is produced at a rapid rate in muscle tissue. What effect does this have on the pH of blood? Why?

Hyperventilation (rapid and deep breathing) can occur during intense exertion. What effect does hyperventilation have on the pH of blood? Why?