This print-out should have 14 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

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001 10.0 points

What is the pH of a solution containing 50 mL of 0.5 M HNO_3 and 150 mL of 0.1 M NaOH?

1. 2.00

2. 1.30 **correct**

3. 0.70

4. 7.00

5. 0.30

Explanation:

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002 10.0 points

According to the Bronsted-Lowry definition, a base is

1. a substance that increases the anion formed by the autoionization of the solvent.

2. None of these

3. a substance that can donate an electron pair to the formation of a covalent bond.

4. a substance that can accept a proton from an acid. **correct**

5. a substance that increases the hydroxide ion concentration in water.

Explanation:

The Bronsted-Lowry theory defines a base as a proton acceptor; the proton acceptor functions as an acid.

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003 10.0 points

According to Lewis theory, an acid is

1. any compound that can donate an electron pair.

2. any compound that can accept a share of an electron pair. **correct**

3. any compound that can accept a proton.

4. any compound containing hydrogen.

5. any compound that can donate a proton.

Explanation:

The Lewis theory of acids and bases defines an acid as an electron pair acceptor.

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004 10.0 points

Which of the following would be expected to act as a Lewis acid?

1. BF_3 **correct**

2. OH^-

3. H_3O^+

4. NH_4^+

5. NH_3

Explanation:

A Lewis acid will have an electron poor region and be able to accept an electron pair. In BF_3 the boron atom is sharing only 6 electrons and therefore would be able to accept an electron pair.

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005 10.0 points

Which acid has the strongest conjugate base?

1. HCl

2. $HClO_2$

3. $HClO_4$

4. $HClO_3$

5. HClO **correct**

Explanation:

The weakest acid will have the strongest conjugate base. Remember that the more oxyzen atoms that surround an acid, the stronger it becomes. This means that HClO is the weakest acid listed above, so it will have the strongest conjugate base.

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006 10.0 points

You have a weak molecular base with $K_\text{b} = 6.6 \times 10^{-9}$. What is the pH of a 0.0500 M solution of this weak base?

1. pH = 9.26 **correct**

2. pH = 3.63

3. pH = 7.12

4. None of these

5. pH = 4.74

Explanation:

[base] = 0.05 M

As mentioned, this is a weak base, so use the equation to calculate weak base $[OH^-]$ concentration:

$$\begin{aligned}[OH^-] &= \sqrt{K_\text{b}\, C_\text{b}} \\ &= \sqrt{(6.6 \times 10^{-9})\,(0.05)} \\ &= 1.81659 \times 10^{-5}\end{aligned}$$

After finding $[OH^-]$, you can find pH using either method below:

A)

$$\text{pOH} = -\log\left(1.81659 \times 10^{-5}\right) = 4.74074$$
$$\text{pH} = 14 - 4.74074 = 9.25926$$

or B)

$$K_\text{w} = [H^+][OH^-] = 1 \times 10^{-14}$$
$$[H^+] = \frac{K_\text{w}}{[OH^-]} = \frac{1 \times 10^{-14}}{1.81659 \times 10^{-5}} = 5.50482 \times 10^{-10}$$
$$\text{pH} = -\log\left(5.50482 \times 10^{-10}\right) = 9.25926$$

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007 10.0 points

A solution of 0.2 M boric acid is prepared as an eye wash. What is the approximate pH of this solution? For boric acid $K_\text{a} = 7.2\times10^{-10}$.

1. pH = 5 **correct**

2. pH = 7

3. pH = 3

4. pH = 4

5. pH = 6

Explanation:

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008 10.0 points

Of the four compounds

HF, $HClO_2$, $NaOH$, $Ba(OH)_2$

which are either strong acids or strong bases in water?

1. All are either strong acids or strong bases.

2. NaOH

3. None are strong acids nor strong bases.

4. $HClO_2$ and NaOH

5. NaOH and $Ba(OH)_2$ **correct**

Explanation:

Memorize the strong acids and strong bases. All others are weak. Only NaOH and $Ba(OH)_2$ are strong; they are strong bases.

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009 10.0 points

What is the pH of a solution containing 0.3 M NH_4Cl and 0.6 M NH_3? The pK_a of the ammonium ion is 9.25.

1. 9.55 **correct**

2. 8.95

3. 12.25

4. 5.05

5. 4.45

Explanation:
For NH_4^+, $pK_a = 9.25$

$$pK_b = pK_w - pK_a = 14 - 9.25 = 4.75$$

$$\begin{aligned} pK_b &= -\log K_b \\ K_b &= 10^{-pK_b} \\ &= 10^{-4.75} = 1.77828 \times 10^{-5} \end{aligned}$$

Building an ICE using molarities,

$NH_3(aq)+H_2O(\ell) \rightleftharpoons$	$NH_4^+(aq)+$	$OH^-(aq)$
0.6		
$-x$	$+x$	$+x$
$0.6 - x$	$0.3 + x$	$+x$

$$K_b = \frac{[NH_4^+]\,[OH^-]}{[NH_3]} = \frac{(0.3 + x)\,x}{0.6 - x} \approx \frac{0.3\,x}{0.6}$$

$$\begin{aligned} x &= \frac{0.6\,K_b}{0.3} = \frac{0.6\,(1.77828 \times 10^{-5})}{0.3} \\ &= 3.55656 \times 10^{-5} = [OH^-] \end{aligned}$$

$$\begin{aligned} [H^+] &= \frac{K_w}{[OH^-]} = \frac{1 \times 10^{-14}}{3.55656 \times 10^{-5}} \\ &= 2.81171 \times 10^{-10} \end{aligned}$$

Thus

$$pH = -\log(2.81171 \times 10^{-10}) = 9.55103$$

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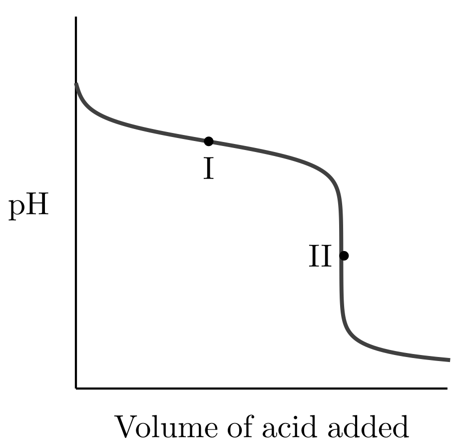
010 10.0 points

Consider the titration curve of a weak base with a strong acid



The pOH at point I is equal to the ___ and the pH at point II is ___ pH 7.

1. pK_b of the base, less than **correct**

2. pH of the base, less than

3. pK_b of the base, equal to

4. pK_b of the base, greater than

5. pH of the base, greater than

Explanation:

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011 10.0 points

Which equation represents K_{a2} for phosphoric acid?

1. $HPO_4^{2-}(aq) + H_2O(\ell) \rightarrow PO_4^{3-}(aq) + H_3O^+(aq)$

2. $H_2PO_4^-(aq) + H_2O(\ell) \rightarrow HPO_4^{2-}(aq) + H_3O^+(aq)$ **correct**

3. $H_3PO_4(aq) + 2\,H_2O(\ell) \rightarrow HPO_4^{2-}(aq) + 2\,H_3O^+(aq)$

4. $H_3PO_4(aq) + H_2O(\ell) \rightarrow H_2PO_4^-(aq) + H_3O^+(aq)$

5. $HPO_4^{2-}(aq) + H_2O(\ell) \rightarrow H_2PO_4^-(aq) + OH^-(aq)$

Explanation:

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012 10.0 points

The pH of 0.010 M $H_3PO_4(aq)$ is 2.24. Estimate the concentration of HPO_4^{2-} in the solution. For H_3PO_4, the values of K_{a1}, K_{a2}, and K_{a3} are 7.6×10^{-3}, 6.2×10^{-8}, and 2.1×10^{-13}, respectively.

1. 6.2×10^{-8} M **correct**

2. 5.8×10^{-3} M

3. 2.1×10^{-13} M

4. 0.010 M

5. 7.6×10^{-3} M

Explanation:

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013 10.0 points

List the bases

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

in order of decreasing strength, if

Base	pK_b	Acid	pK_a
$(C_2H_5)_3N$	2.99	HBrO	8.69
N_2H_4	5.77	HCN	9.31

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

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

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

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

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

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

7. None of these

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

9. N_2H_4, CN^-, BrO^-, $(C_2H_5)_3N$

Explanation:

The stronger the base, the larger its K_b value and the smaller its pK_b value from p$K_b = -\log K_b$.

To find the pK_b for the conjugate base of a weak acid, use pK_a + pK_b = 14.

Thus we have

N_2H_4 (weakest)	(pK_b = 5.77)
BrO^-	(pK_b = 14.0 − 8.69 = 5.31)
CN^-	(pK_b = 14.0 − 9.31 = 4.69)
$(C_2H_5)_3N$ (strongest)	(pK_b = 2.99)

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014 10.0 points

What would be the pH of a solution prepared from 2 L of 0.05 M HClO and 1 L of 3.16 M NaClO? The K_a of chlorous acid is 3.16×10^{-8}.

1. 6

2. 7.5

3. 9 **correct**

4. 9.3

Explanation:

Because this is a buffer, it is acceptable to use moles in place of concentrations

$$\begin{aligned}[H^+] &= K_a(C_a/C_b) \\ &= \left(3.16 \times 10^{-8}\right)(0.1 \text{ M}/3.16 \text{ M}) \\ &= 1 \times 10^{-9}\end{aligned}$$

pH = 9