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

001 10.0 points

Which K_a value(s) would you use when calculating the pH of a system involving Li_2HPO_4 and Li_3PO_4?

1. K_{a2}, K_{a3}

2. K_{a1}

3. K_{a2}

4. K_{a3} **correct**

5. K_{a1}, K_{a2}

Explanation:

002 10.0 points

One difference between a Lewis base and an Arrhenius base is

1. a Lewis base is a proton acceptor and an Arrhenius base produces hydroxide ions in solution.

2. a Lewis base is an electron pair acceptor and an Arrhenius base is a proton acceptor.

3. a Lewis base is an electron pair donor and an Arrhenius base is a proton acceptor.

4. a Lewis base is an electron pair acceptor and an Arrhenius base is a proton donor.

5. a Lewis base is an electron pair donor and an Arrhenius base produces hydroxide ions in solution. **correct**

Explanation:

A base is defined by the Arrhenius theory as a substance which in water produces OH ions, and by the Lewis theory as a species which provides an electron pair for sharing in a coordinate covalent bond.

003 10.0 points

Which of the acids

I. $HBrO_3$ II. $GaCl_3$ III. HSO_4^- IV. AlF_3

are classified as Lewis acids but are not Bronsted-Lowry acids?

1. I and II

2. II and IV **correct**

3. None of these

4. II and III

5. I and IV

Explanation:

Lewis acids accept a share in an electron pair. A Bronsted-Lowry acid is a proton donor. I and III would be Bronsted acids. Therefore, only II and IV can be the correct answer.

004 10.0 points

Listed in order of increasing acid strength, which pair is incorrect?

1. $HNO_3 < HNO_2$ **correct**

2. $H_3AsO_4 < H_3PO_4$

3. $HF < HCl$

4. $H_3As < H_2Se$

5. $HClO < HClO_2$

Explanation:

In a group of the Periodic Table, acid strength decreases as the metallic character of element E in H_xEO_y increases. Acid strength increases as the number of oxygen atoms in the formula increases for a given element X in HXO_y. HF is a weak acid and HCl is a strong acid.

005 10.0 points

Which one of the following pairs of acids and their conjugate bases is INCORRECTLY

matched?

1. $H_2O : OH^-$

2. $H_3O^+ : H_2O$

3. $HClO : ClO^-$

4. $NH_4^+ : NH_2^-$ **correct**

5. $HF : F^-$

Explanation:
An acid is a proton donor and a base is a proton acceptor. The only difference between the acid and its conjugate base is that the base has one less H atom. NH_2^- has two fewer H atoms than the NH_4^+; therefore, it is incorrectly matched.

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006 10.0 points

A 0.0001 M solution of HCl has a pH of

1. 11.

2. 10.

3. 3.

4. 4. **correct**

Explanation:
$[HCl] = 0.0001$ M
HCl is a strong acid which means it dissociates completely into $[H^+]$ and $[Cl^-]$. Therefore, we know that the concentration of $[H^+]$ is 0.0001 M.

$$pH = -\log[H^+] = -\log(0.0001) = 4\,.$$

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007 10.0 points

Arrange the acids
I) phosphorous acid (H_3PO_3), $pK_{a1} = 2.00$;
II) hydrogen selenate ion ($HSeO_4^-$), $pK_a = 1.92$;
III) phosphoric acid (H_3PO_4), $pK_a = 2.12$;
IV) selenous acid (H_2SeO_3), $pK_a = 2.46$;
in *increasing* order of strengths.

1. Cannot be determined

2. II, I, III, IV

3. None of these

4. III, I, IV, II

5. II, IV, I, III

6. IV, I, III, II

7. II, III, IV, I

8. IV, III, I, II **correct**

9. I, IV, III, II

10. II, III, I, IV

Explanation:
The stronger the acid, the higher the K_a value and the lower the pK_a value:

$$pK_a = -\log(K_a)$$
$$K_a = 10^{-pK_a}$$

I. For phosphorous acid,

$$K_a = 10^{-2.00} = 0.01$$

II. For the hydrogen selenate ion,

$$K_a = 10^{-1.92} = 0.0120226$$

III. For phosphoric acid,

$$K_a = 10^{-2.12} = 0.00758578$$

IV. For selenous acid,

$$K_a = 10^{-2.46} = 0.00346737$$

$$H_2SeO_3 < H_3PO_4 < H_3PO_3 < HSeO_4^-$$

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008 10.0 points

Which of
I) HCl II) HF III) LiOH

IV) $HClO_2$ V) HNO_3
are strong acids or strong bases in water?

1. All of the compounds

2. I, III, and V only **correct**

3. I, II, IV, and V only

4. I, III, IV, and V only

5. I, II, III, and V only

Explanation:

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009 10.0 points

Assume that five weak acids, identified only by numbers (1, 2, 3, 4 and 5), have the following ionization constants.

Acid	Ionization Constant K_a value
1	1.0×10^{-3}
2	3.0×10^{-5}
3	2.6×10^{-7}
4	4.0×10^{-9}
5	7.3×10^{-11}

The anion of which acid is the weakest base?

1. 3

2. 5

3. 2

4. 4

5. 1 **correct**

Explanation:

$$HA \rightleftharpoons H^+ + A^-$$

$$K_a = \frac{[H^+]\,[A^-]}{[H]\,[A]}$$

The 'anion of an acid' is another way of saying 'conjugate base,' and a weak conjugate base corresponds to a strong acid. So really what we're looking for is which acid is strongest (has the lowest pH).

A low pH means that the $[H^+]$ concentration is low. (Remember that values greater than 7 are basic!) The larger values of K_a means that there is more $[H^+]$ so you would expect these solutions to be more acidic; *i.e.*, have smaller pH's. The smaller K_a values mean less $[H^+]$ in solution, so higher pH's. The acid with the largest K_a (#1) will have the lowest pH; *i.e.*, highest $[H^+]$ concentration

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010 10.0 points

What is the pH of 2×10^{-9} M $Ba(OH)_2$?

1. 8.40

2. 8.70

3. 7.02 **correct**

4. 5.60

5. 5.30

Explanation:
$[Ba(OH)_2] = 2 \times 10^{-9}$ M $\quad K_w = 1 \times 10^{-14}$
$Ba(OH)_2$ completely dissociates:

$$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2\,OH^-(aq)$$

$$[OH^-] = 2\,[Ba(OH)_2]$$
$$= 2\,(2 \times 10^{-9}) = 4 \times 10^{-9}$$

which is less than the $[OH^-]$ in pure water (1×10^{-7}), so we must consider this concentration:

	$H_2O \rightleftharpoons$	H^+	+	OH^-
ini	–	1×10^{-7}		1×10^{-7}
Δ	–	-4×10^{-9}		$+4 \times 10^{-9}$
fin		9.6×10^{-8}		1.04×10^{-7}

$$K_w = [OH^-]\,[H^+]$$

$$[H^+] = \frac{K_w}{[OH^-]}$$

$$= \frac{1 \times 10^{-14}}{1.04 \times 10^{-7}}$$
$$= 9.61538 \times 10^{-8}$$

Thus

$$\mathrm{pH} = -\log[\mathrm{H}^+]$$
$$= -\log(9.61538 \times 10^{-8}) = 7.01703$$

Remember to check if your pH makes sense. The usual error here is to just substitute the $[\mathrm{OH}^-]$ from the $\mathrm{Ba(OH)_2}$ alone into the K_w expression to find $[\mathrm{H}^+]$; this gives an *acidic* pH value for the *base* $\mathrm{Ba(OH)_2}$.

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011 10.0 points

For a solution labeled "0.10 M $\mathrm{H_2SO_4(aq)}$,"

1. $[\mathrm{HSO_4^-}]$ is greater than 0.10 M.

2. the pH is less than 1.0. **correct**

3. $[\mathrm{SO_4^{2-}}] = 0.10$ M.

4. the pH equals 1.0.

5. the pH is greater than 1.0.

Explanation:

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012 10.0 points

Estimate the pH of 0.10 M $\mathrm{Na_2HPO_4(aq)}$ given $\mathrm{p}K_{\mathrm{a}1} = 2.12$, $\mathrm{p}K_{\mathrm{a}2} = 7.21$, and $\mathrm{p}K_{\mathrm{a}3} = 12.68$ for phosphoric acid.

1. 4.67

2. 7.40

3. 9.94 **correct**

4. 2.12

5. 12.68

Explanation:

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013 10.0 points

Consider the titration of equal volumes of 0.1 M HCl and 0.1 M $\mathrm{HC_2H_3O_2}$ with 0.1 M NaOH. Which of the following would be the same for both titrations?

1. the volume of NaOH added to reach the equivalence point **correct**

2. the pH at the halfway point

3. the pH at the equivalence point

4. the initial pH

5. Two of the other answers are correct.

Explanation:

Both HCl and $\mathrm{CH_2C_3O_2H_2}$ are monoprotic acids and so if the volume concentrations are identical, the amounts of replaceable H^+ in both solutions are identical.

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014 10.0 points

What would be the pH of a solution of hypobromous acid (HOBr) prepared by dissolving 9.7 grams of the acid in 20 mL of pure water ($\mathrm{H_2O}$)? The Ka of hypobromous acid is 2×10^{-9}

1. 13

2. 1

3. 10

4. 4 **correct**

5. 6

Explanation:

$$9.7 \text{ g HOBr} \times \frac{1 \text{ mol}}{97 \text{ g}} = 0.1 \text{ mol HOBr}$$

$$\frac{0.1 \text{ mol HOBr}}{0.02 \text{ L } \mathrm{H_2O}} = 5 \text{ M HOBr}$$

$$[\mathrm{H}^+] = (\mathrm{K_a} \cdot \mathrm{C_a})^{1/2} = (2 \times 10^{-9} \cdot 5)^{1/2}$$
$$= (10^{-8})^{1/2} = 10^{-4}$$
$$\mathrm{pH} = -\log[\mathrm{H}^+] = -\log(10^{-4}) = 4$$