ChemQuest 20



Information: Polyatomic Ions

The word, "polyatomic" means "many atoms". A polyatomic ion, therefore, is an ion that is made of more than one atom. An example of a polyatomic ion is the sulfate ion, $SO_4^{2^-}$. Sulfate is composed of one sulfur atom and four oxygen atoms and overall sulfate has a negative two charge. Some polyatomic ions:

Sulfate: SO₄²⁻ Phosphate: PO₄³⁻ Nitrate: NO₃⁻ Cyanide: CN⁻ Ammonium: NH₄⁺ Chlorate: ClO₃⁻ Acetate: C₂H₃O₂⁻ Hydroxide: OH⁻ Carbonate: CO₃²⁻

Critical Thinking Questions

1. What do all of the polyatomic ions that have the suffix "-ate" have in common? They all contain oxygen atoms.

- 2. Which two atoms do you think compose the polyatomic ion called "silicate"? silicon and oxygen
- 3. What is the difference between calcium nitride and calcium nitrate?

 The –ate ending indicates that calcium nitrate has oxygen in it, but calcium nitride does not.

Information: Writing Formulas With Polyatomic Ions

First of all, you must remember that you can never change the formula for a polyatomic ion. Sulfate is <u>always</u> SO_4^{2-} and never $S_2O_8^{4-}$ or something else. Following are some examples of chemical formulas that contain polyatomic ions.

Ammonium chloride is formed from one ammonium ion (NH_4^+) and one chloride ion (Cl^-) to give the formula: NH_4Cl . Sodium sulfate requires two sodium ions (Na^+) because sulfate (SO_4^{-2-}) has a negative two charge; the formula is: Na_2SO_4 .

Consider calcium hydroxide. Calcium has a positive two charge (Ca²⁺) and hydroxide has a negative one charge (OH⁻). We need two hydroxide ions to combine with one calcium ion so that the overall charge ends up being zero. We write calcium hydroxide like Ca(OH)₂.

Following are some more examples:

potassium acetate: $KC_2H_3O_2$ magnesium nitrate: $Mg(NO_3)_2$ barium phosphate: $Ba_3(PO_4)_2$ calcium carbonate: $CaCO_3$

Critical Thinking Questions

4. As mentioned above, calcium hydroxide is written like Ca(OH)₂. Why can't it be written like CaOH₂?

Ca(OH)₂ means that two OH⁻ have bonded with a Ca²⁺ ion. CaOH₂ means that two H⁺ ions have bonded with one O²⁻ ion and a Ca²⁺ ion. CaOH₂ is not a neutral compound.

5. As mentioned above, barium phosphate is written as $Ba_3(PO_4)_2$. Why can't it be written like Ba_3PO_{42} ?

 $Ba_3(PO_4)_2$ means that two $PO_4^{3^-}$ ions have bonded with three Ba^{2^+} ions. Ba_3PO_{42} means that three Ba^{3^+} ions have bonded with one P^{3^-} ion and 42 O^{2^-} ions, which would not yield a neutral compound.

6. Name the following compounds. Each includes at least one polyatomic ion.

a) Na₃PO₄ b) (NH₄)₂SO₄ c) Mg(C₂H₃O₂)₂ sodium phosphate ammonium sulfate magnesium acetate

d) (NH₄)₂S e) CaCO₃ f) Ba(NO₃)₂ ammonium sulfide calcium carbonate barium nitrate

7. Write formulas for the following ionic compounds. Note that each includes a polyatomic ion.

a) lithium phosphate b) ammonium oxide c) barium hydroxide Li_3PO_4 $(\text{NH}_4)_2\text{O}$ $\text{Ba}(\text{OH})_2$

d) calcium cyanide e) sodium chlorate f) potassium sulfate $Ca(CN)_2$ NaClO₃ K_2SO_4

8. In question 3, you were asked the difference between calcium nitride and calcium nitrate. Now write the formula for each of them.

calcium nitride: Ca₃N₂ calcium nitrate: Ca(NO₃)₂

Information: Formulas for Acids

Acids are compounds that contain positive hydrogen ions (H^+) bonded to a negative ion. For example, carbonic acid is formed when the carbonate ion (CO_3^{2-}) bonds with two hydrogen ions (H^+) to give H_2CO_3 . Other common acids are listed below:

Hydrochloric acid: HCl Sulfuric acid: H₂SO₄ Nitric Acid: HNO₃ Acetic Acid: HC₂H₃O₂

Critical Thinking Questions

- 9. Why do carbonic and sulfuric acid require two H⁺ ions to bond, but HCl and HNO₃ only have one H⁺? Carbonate and sulfate both have a -2 charge and therefore require two H⁺ ions (each having a +1 charge) so that overall the formulas will be neutral.
- 10. Phosphoric acid is made from the phosphate ion and H⁺ ions. Write the formula for phosphoric acid.

H₃PO₄ Three H⁺ ions are needed because phosphate has a -3 charge.