Please complete the guiding questions after reading the article entitled “Sustainable Production of Reduced Phosphorus Compounds: Mechanochemical Hydride Phosphorylation Using Condensed Phosphates as a Route to Phosphates” by Zhai, Xin, Geeson, and Cummins. *ACS Central Science* **2022**, *8*(3), 332–339. <https://doi.org/10.1021/acscentsci.1c01381>

Also refer to *ACS Central Science* **2020**, *6*(6), 848–860 for additional information on phosphorus chemistry and the phosphorus industry. <https://doi.org/10.1021/acscentsci.0c00332>

For further reading about the history of phosphorus as an element, see the Book “The 13th Element: The Sordid Tale of Murder, Fire, and Phosphorus” by John Emsley.

Questions:

1. What is the oxidation state of P in each of the following species?



1. What is the other common allotrope of phosphorus besides white phosphorus? Describe the properties and applications of white phosphorus and the other common allotrope.
2. White phosphorus is currently produced through the “thermal process,” in which phosphate rock (Ca3(PO4)2) is reduced with charcoal (C) in the presence of silica (SiO2) at 1500 K in an electric arc furnace. The products are P4, CaSiO3, and CO. Please balance the chemical equation: Ca3(PO4)2 + C + SiO2 -> CaSiO3 + P4 + CO. Briefly describe the environmental consequences of the “thermal process.”
3. What chemical reactivity do alkali metal hydrides exhibit in general?
4. What is the main benefit of mechanochemistry compared to traditional methods?
5. Why did the authors choose mechanochemical methods rather than conventional solution methods to achieve the reaction between phosphates and KH?
6. Selectivity was a key problem with the reaction of KH and phosphate sources. What is the desired product, and how is it currently made? What is the over-reduction product?
7. Explain the authors’ mechanistic proposal on the formation of hypophosphite (H2PO2–) during the KH reduction of sodium triphosphate (Na5P3O10).
8. Why does biologically-derived polyphosphate need to be calcined prior to reduction with KH?