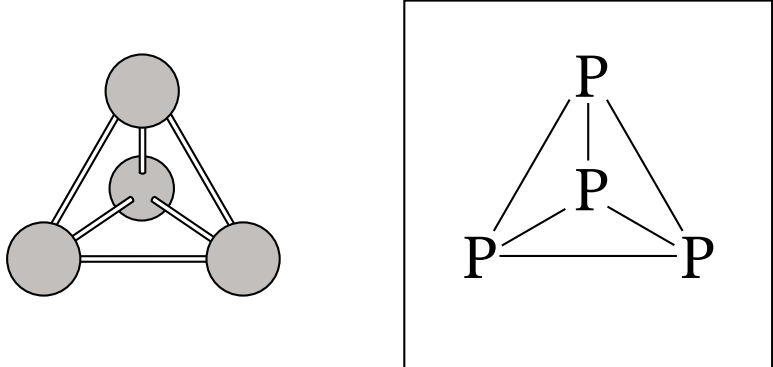
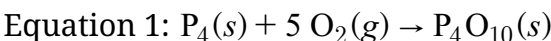


3. White phosphorus is composed of P_4 molecules with a tetrahedral structure, as shown in the diagram on the left. Each P atom is bonded to the other three P atoms by single bonds, as shown in the incomplete Lewis diagram on the right.



A. In the box in part A, complete the Lewis diagram for P_4 by drawing the nonbonding electrons.

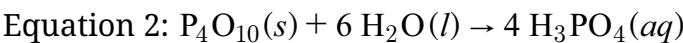
B. The reaction of white phosphorus with oxygen to form $\text{P}_4\text{O}_{10}(s)$ is thermodynamically favorable at 298 K. The reaction is represented by equation 1.



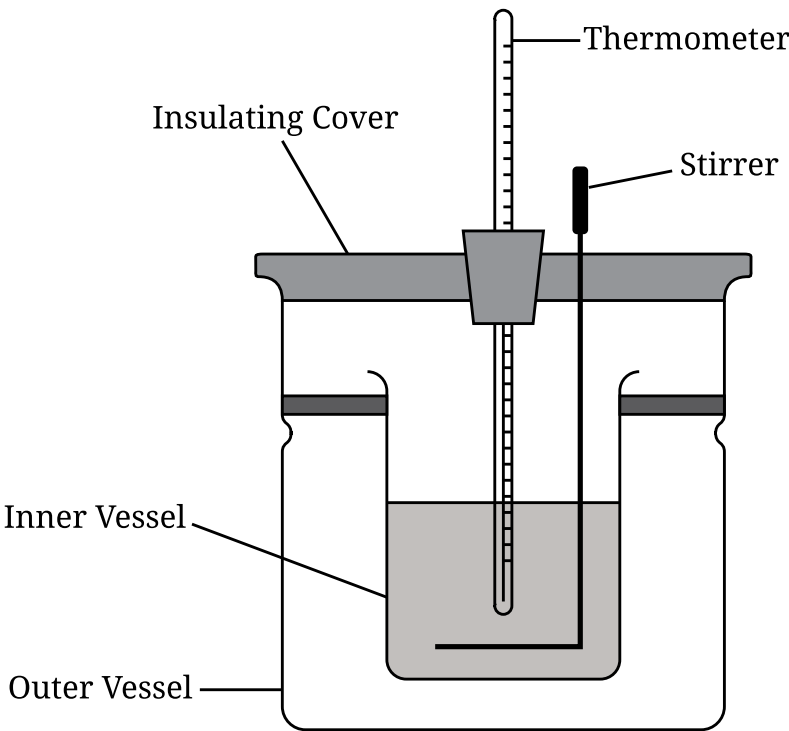
- i. The entropy change of the reaction, ΔS° , is negative. Using particle-level reasoning, explain why the entropy decreases as the reaction progresses.
- ii. The enthalpy change of the reaction, ΔH° , is also negative. A student claims that the favorability of the reaction is driven by enthalpy and **not** by entropy. Is the student’s claim correct? Justify your answer by using the relationship between ΔG° , ΔH° , and ΔS° .

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$\text{P}_4\text{O}_{10}(s)$ reacts exothermically with water to form phosphoric acid, as represented by equation 2.



A chemist uses a calorimetry experiment to determine the enthalpy change for the reaction, as represented by the following diagram.



C. The chemist carries out the calorimetry experiment and records the following information.

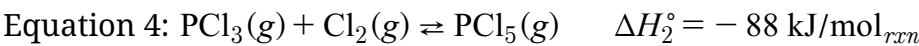
Mass of P_4O_{10}	0.100 g
Mass of H_2O	100.0 g
Initial temperature	22.00° C
Final temperature	22.38° C
Molar mass of P_4O_{10}	283.9 g/mol
Specific heat of H_2O	4.18 J/(g·°C)

- i. Calculate the amount of heat, q , released during the experiment, in kJ. Assume that the specific heat of the solution is the same as that of water.
- ii. Calculate the value of ΔH_{rxn}° for equation 2 in kJ/mol $_{rxn}$. Include the sign in your answer.

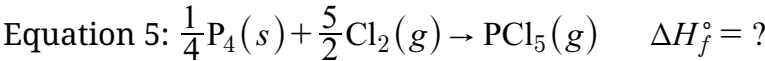
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D. The chemist weighed out 0.100 g P_4O_{10} of and 100.0 g of H_2O to perform a second trial. In the second trial, some of the solid P_4O_{10} stuck to the weighing paper and was not transferred to the calorimeter. Given that P_4O_{10} is the limiting reactant, would ΔT for the second trial be greater than, less than, or equal to the value in the first trial? Justify your answer.

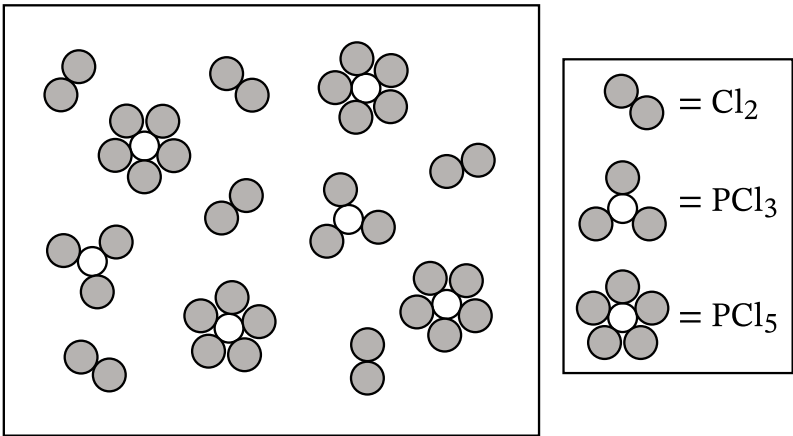
$\text{P}_4(s)$ also reacts readily with $\text{Cl}_2(g)$ to produce phosphorus trichloride, $\text{PCl}_3(g)$, which in turn reacts with $\text{Cl}_2(g)$ in an equilibrium process to produce $\text{PCl}_5(g)$. The reactions are represented by equations 3 and 4.



E. Calculate the standard enthalpy of formation of $\text{PCl}_5(g)$ represented by equation 5.



The following particle-level diagram represents the contents of the vessel in an equilibrium mixture at 546 K involving equation 4.



F. Equation 4 for the reaction that occurs is shown.



- i. If each particle in the diagram represents a partial pressure of 1.00 atm, what is the value of K_p for the equilibrium mixture at 546 K?
- ii. Does the value of K_p increase, decrease, or remain the same when the temperature is increased to 596 K? Justify your answer based on ΔH_2° .