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.

$P_4(s)$ also reacts readily with $Cl_2(g)$ to produce phosphorus trichloride, $PCl_3(g)$, which in turn reacts with $Cl_2(g)$ in an equilibrium process to produce $PCl_5(g)$. The reactions are represented by equations 3 and 4.

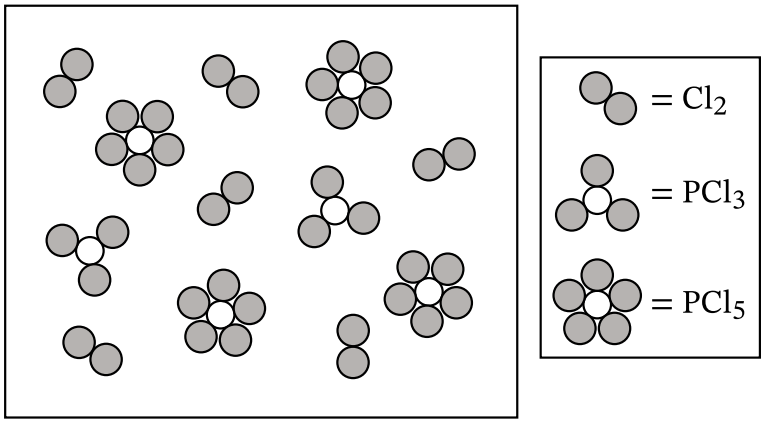
Equation 3: $P_4(s) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(g) \qquad \Delta H_1^\circ = -1148\ \text{kJ/mol}_{rxn}$

Equation 4: $PCl_3(g) + Cl_2(g) \rightleftarrows PCl_5(g) \qquad \Delta H_2^\circ = -88\ \text{kJ/mol}_{rxn}$

E. Calculate the standard enthalpy of formation of $PCl_5(g)$ represented by equation 5.

Equation 5: $\frac{1}{4}P_4(s) + \frac{5}{2}Cl_2(g) \rightarrow PCl_5(g) \qquad \Delta H_f^\circ = ?$

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.

Equation 4: $PCl_3(g) + Cl_2(g) \rightleftarrows PCl_5(g) \qquad \Delta H_2^\circ = -88\ \text{kJ/mol}_{rxn}$

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°.

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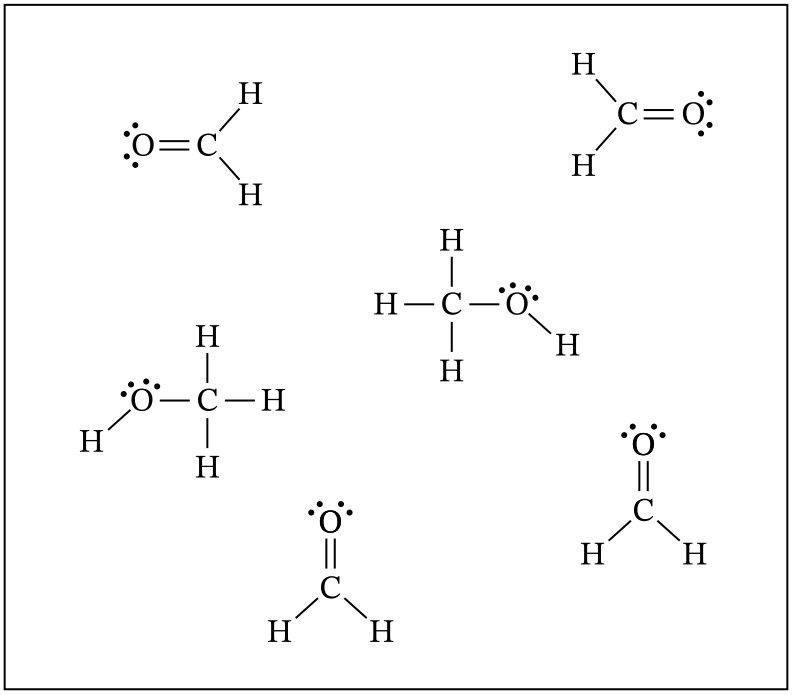
4. A scientist is investigating the properties of a mixture of CH_3OH and H_2CO. The scientist generates the following diagram to represent the mixture.



A. Identify the hybridization of the valence orbitals of the C atom in the H_2CO molecule.

B. In the diagram provided, draw a SINGLE dashed line (----) to represent a strong hydrogen-bonding attraction between one CH_3OH molecule and one H_2CO molecule in the mixture.

C. The scientist plans to cool a gaseous mixture of CH_3OH and H_2CO to form a liquid mixture and finds data on the two compounds. The data are summarized in the table.

Substance	Melting Point (K)	Boiling Point (K)	Enthalpy of Vaporization (kJ/mol)
CH_3OH	176	338	37.6
H_2CO	181	254	24.2

i. Propose a temperature to which the mixture should be cooled such that CH_3OH and H_2CO will both be liquids.

ii. The scientist analyzes the mixture after it is cooled and determines that 8.59 g of $CH_3OH(l)$ is present. Calculate the amount of thermal energy, in kJ, that was removed to condense the 8.59 g of CH_3OH (molar mass 32.04 g/mol) at its boiling point.

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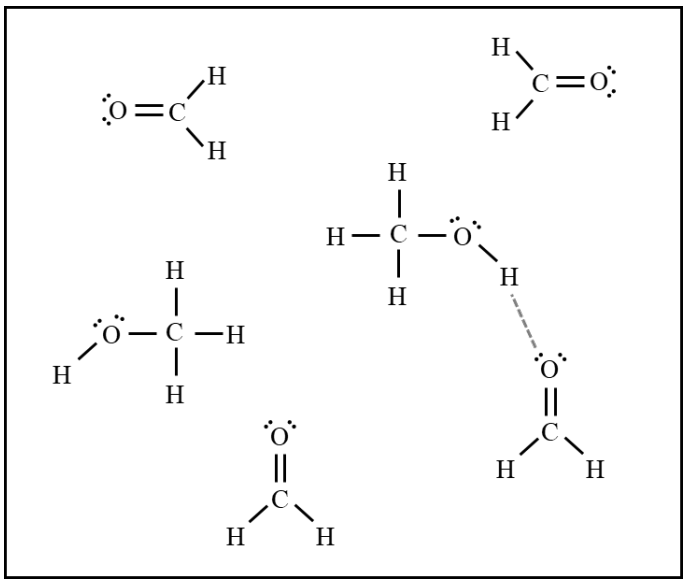
Question 4: Short Answer — 4 points

A For the correct answer: **Point 01**

sp^2

B For a correct diagram: **Point 02**

The diagram should show a dashed line between the O *atom in one* H_2CO *molecule and the* H *atom in the* –OH *group of one* CH_3OH *molecule. See example response below.*



C (i) For a correct proposal: **Point 03**

The proposed temperature should be in the range 181 K – 254 K .

(ii) For the correct calculated value: **Point 04**

$$8.59 \text{ g } CH_3OH \times \frac{1 \text{ mol } CH_3OH}{32.04 \text{ g } CH_3OH} \times \frac{-37.6 \text{ kJ}}{1 \text{ mol } CH_3OH} = -10.1 \text{ kJ}, \textit{ so } 10.1 \text{ kJ } \textit{are removed.}$$

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