34.14 Prior to compression, ideal air in an Otto cycle is at $70°F$ and $14.7psia$. The volumetric pressure ratio is $8.5 : 1$. The maximum pressure during the cycle is $450psia$. What is the highest temperature achieved during the cycle?

A. $790°F$

B. $1250°F$

C. $1450°F$

D. $1900°F$

Refer to the Otto Cycle P-v and T-s diagrams for identifying the states of the Otto Cycle. State 1 prior to compression is fully defined.

$$P_1 = 14.7psia$$

$$T_1 = 70°F$$

The process from State 1 to State 2 in an Otto Cycle is isentropic compression. Since air is assumed to be ideal, use the equation for a Constant Entropy Process where the volumetric pressure ratio is known. Use absolute temperatures i.e. Rankine.

$$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$T_2 = T_1 \left(\frac{v_1}{v_2}\right)^{k-1} = (530R)(8.5)^{(1.4-1)} = 1247.5R$$

To find the pressure at State 2, treat air as an Ideal Gas where pressure, volume, and temperature are interrelated.

$$\frac{P_1 v_1}{T_1} = \frac{P_2 v_2}{T_2}$$

$$P_2 = P_1 \left(\frac{T_2}{T_1}\right)\left(\frac{v_1}{v_2}\right) = (14.7psia)\left(\frac{1247R}{530R}\right)(8.5) = 294.1psia$$

The maximum pressure in the cycle occurs at State 3. The process from State 2 to State 3 is constant volume heating. Treating air as an ideal gas, the change in temperature is directly proportional to the change in pressure. Convert to Farenheit for the final answer.

$$\frac{T_3}{T_2} = \frac{P_3}{P_2}$$

$$T_3 = T_2 \left(\frac{P_3}{P_2}\right) = 1247.5R\left(\frac{450psia}{294.1psia}\right) = 1909R = 1449°F$$

Answer C