34.7 **$70°F$ atmospheric air enters an 80% efficient compressor with a compression ratio of 10. What is the exit temperature? Assume a ratio of specific heats of $k = 1.4$.**

A. $122°F$

B. $465°F$

C. $687°F$

D. $925°F$

Consider the air entering the compressor as State 1 and the air leaving the compressor as State 2. Start by finding the *ideal* exit temperature inititally assuming the compression is a Constant Entropy Process. The ratio $\frac{P_2}{P_1}$ is the compression ratio which is given. Use absolute temperatures i.e. Rankine and convert to Farenheit at the end.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\left(\frac{k-1}{k}\right)}$$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\left(\frac{k-1}{k}\right)} = (530R)\,(10)^{\frac{1.4-1}{1.4}} = 1023.3R = 563.3°F$$

Find the *actual* exit temperature by applying the efficiency. The efficiency is a ratio of the ideal work to the actual work, which for ideal air can be approximated using constant specific heat capacities, which appears in both the numerator and denominator and thus cancels out of the expression. The enthalpy of air is then a function of the temperature only, which is a common simplifying assumption for low pressure conditions.

$$\eta = \frac{w_{ideal}}{w_{actual}} \approx \frac{c_p\,(T_2 - T_1)}{c_p\,(T_2^{'} - T_1)}$$

$$T_2^{'} = T_1 + \frac{(T_2 - T_1)}{\eta} = 70°F + \frac{(563.3°F - 70°F)}{0.8} = 686.6°F$$

Answer C