A heat engine takes in 100 J of heat and performs 60 J of work in each cycle. If its maximum temperature is $T_H = 600 \text{ K}$, what at most can be inferred about its minimum (exhaust) temperature, $T_C$?

1. $T_C > 600 \text{ K}$
2. $T_C > 540 \text{ K}$
3. $T_C > 500 \text{ K}$
4. $T_C > 360 \text{ K}$
5. $T_C > 240 \text{ K}$
6. None of above
One concludes that the exhaust temperature, \( T_C < 240 \, \text{K} \) (i.e. answer (d)), as follows:

- \( \eta_{\text{ACTUAL}} < \eta_{\text{CARNOT}} \) implies
- (i) \( 1 - (Q^{\text{OUT}}/Q^{\text{IN}}) < 1 - (T_C/T_H) \), so that
- (ii) \( (Q^{\text{OUT}}/Q^{\text{IN}}) > (T_C/T_H) \), or
- (iii) \( T_H \ast (Q^{\text{OUT}}/Q^{\text{IN}}) > T_C \).
- Since (1\text{st} Law, with \( \Delta U = 0 \)):
  - (iv) \( Q^{\text{IN}} - Q^{\text{OUT}} = W^{\text{OUT}} \)
- Or (v) \( Q^{\text{IN}} - W^{\text{OUT}} = Q^{\text{OUT}} \), (iii) becomes
  - (vi) \( (Q^{\text{IN}} - W^{\text{OUT}})/Q^{\text{IN}}) \ast T_H > T_C \) and compute
  - \( ((100 - 60)/100) \ast 600 \, \text{K} > T_C \)
  - or \( 240 \, \text{K} > T_C \).