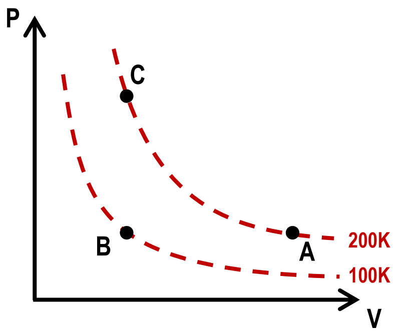
CONCEPT: CALCULATING WORK IN HEAT ENGINES USING PV DIAGRAMS

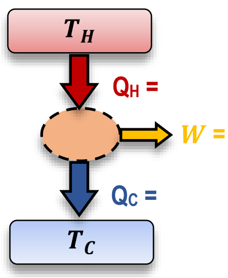
- Remember: Heat engines are cyclic processes. On PV diagrams, they *always* run in ______________ loops.
- Remember: For heat engines, $W = Q_H - Q_C = Q_{IN} - Q_{OUT}$.

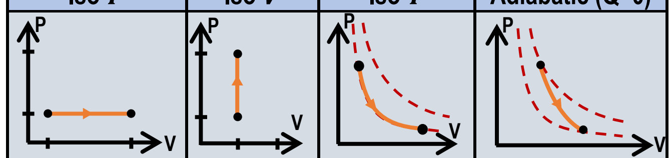
  Q_H = heat added INTO the system (from **Hot Reservoir**), i.e. the **SUM** of all **[+ | –]** Qs over the cycle.

  Q_C = heat removed OUT of the system (to **Cold Reservoir**), i.e. the **SUM** of all **[+ | –]** Qs over the cycle.

EXAMPLE: 2 mol of a monoatomic gas follows the cyclic process used in a heat engine. Heat is removed from the gas at constant pressure from **A**→**B**, added at constant volume from **B**→**C**, then the gas expands isothermally from **C**→**A**, doing 2300J of work, and repeats. Calculate **a)** the heat transfer of each process; **b)** the total work done by the heat engine.







	Iso-P	Iso-V	Iso-T	Adiabatic (Q=0)
ΔE_{int}	$Q - W$	$\Delta E_{int} = Q$	0	$\Delta E_{int} = -W$
Q	$nC_P\Delta T$	$nC_V\Delta T$	$Q = W$	0
W	$P\Delta V$	0	$nRT \cdot \ln\left(\frac{V_f}{V_i}\right)$	$-nC_V\Delta T$ OR $\frac{1}{\gamma-1}(P_iV_i - P_fV_f)$
				$P_iV_i^{\gamma} = P_fV_f^{\gamma}$ $T_iV_i^{\gamma-1} = T_fV_f^{\gamma-1}$

GAS TYPE	C_V	C_P
Monoatomic	$\frac{3}{2}R$	$\frac{5}{2}R$
Diatomic	$\frac{5}{2}R$	$\frac{7}{2}R$

EQs & Constants

$\Delta E_{int,OF} = Q_{TO} - W_{BY}$

$\Delta E_{int} = 0$

$|W| = |Q_H| - |Q_C|$

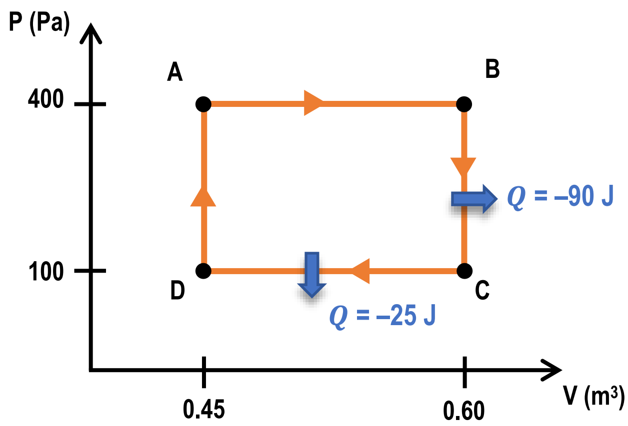
$e = \frac{\text{output}}{\text{input}} = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$

$K = \frac{Q_C}{W}$

$K_{HP} = \frac{Q_H}{W}$

$R = 8.314$

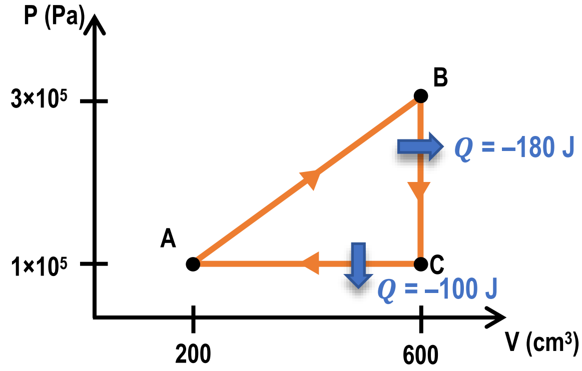
PROBLEM: For the heat engine shown in the PV diagram below, calculate: **a)** the work done; **b)** the total heat transferred from the hot reservoir.



HEAT ENGINES	
$\Delta E_{int} = 0$	
$\lvert W \rvert = \lvert Q_H \rvert - \lvert Q_C \rvert$	
$e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$	
$Q = nC_V\Delta T$	(Constant V)
$Q = nC_P\Delta T$	(Constant P)
$W = -nRT\ ln\left(\frac{V_f}{V_i}\right)$	(Constant T)

PROBLEM: A heat engine follows the cycle shown below. What is the thermal efficiency (%) of this engine?

A) 58.8%
B) 99.9%
C) 14.3%
D) 12.5%



HEAT ENGINES

$\Delta E_{int} = 0$

$|W| = |Q_H| - |Q_C|$

$e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$

$Q = nC_V\Delta T$ (Constant V)

$Q = nC_P\Delta T$ (Constant P)

$W = -nRT\ ln\left(\frac{V_f}{V_i}\right)$ (Constant T)