THERMODYNAMICS 1 – IE n°2 – marking sheet

Exercice1 : Otto Cycle Thermal Machine (14 points)

Study of the cycle	*9.5 points*
1) The studied sytem lies within the combustion chamber.	0.5
2) Transformations are adiabatic because they are too fast for heat transfer to occur.	0.5

3) $n = P_A V_A / RT_A = 0.0283$ mol = 28.3 mmol

$P_B = P_A (V_A/V_B)^\gamma$ et $P_D = P_C (V_C/V_D)^\gamma$

$T_B = P_B V_B/nR$ et $T_D = P_D V_D/nR$

$P_C = nRT_C/V_C$

	P (en Pa)	V (en cm^3)	T (en K)
A	10^5	800	340
B	$21,3 \times 10^5$	90	815
C	$63,5 \times 10^5$	90	2430
D	$2,98 \times 10^5$	800	1015

inconnues P_B, T_B, P_C, P_D, T_D

2.5 = 5 × 0.5

4) Transformation AB adiabatique réversible :

$Q_{AB} = 0$ car transformation adiabatique

$W_{AB} = \Delta U_{AB} = n\overline{C_V}(T_B - T_A) = = 279,3$ J

Transformation BC isochore brutale:

$W_{BC} = 0$ car transformation isochore

$Q_{BC} = \Delta U = n\overline{C_V}(T_C - T_B) = = 949,5$ J

Transformation CD adiabatique réversible :

$Q_{CD} = 0$ car transformation adiabatique

$W_{CD} = \Delta U_{CD} = n\overline{C_V}(T_D - T_C) = -831,9$ J

Transformation DA isochore brutale:

$W_{DA} = 0$ car transformation isochore

$Q_{DA} = \Delta U = n\overline{C_V}(T_A - T_D) = -396,9$ J

	A → B	B → C	C → D	D → A
W (J)	279,3	0	-831,9	0
Q (J)	0	949,5	0	-396,9

4 = 8×0.5

$W_T = -552,6$ J c'est un moteur — **0.5**

5) adiab : no $S_{exchanged}$, rev : no $S_{created}$ so $\Delta S_{AB} = 0$ and $\Delta S_{CD} = 0$ — **1.5 = 3×0.5**

$\Delta S_{BC} = \int \delta Q_{rev}/T = \int n\overline{C_V}\, dT/T = n\overline{C_V}\, ln(T_C/T_B) = 0.643$ J/K;

$\Delta S_{DA} = n\overline{C_V}\ \ln(T_A/T_D) = -0.644$ J/K;

$\Delta S_{cycle} = 0$ car transformation cyclique et S fct d'état — **0.5**

Performance study	*2 points*
6) $CoP = \frac{W_T}{Q_{BC}} = \frac{Q_{BC} + Q_{DA}}{Q_{BC}} = \frac{(T_A - T_B + T_C - T_D)}{(T_C - T_B)} = 1 + \frac{(T_A - T_D)}{(T_C - T_B)} = 58,3\%$	0.5
7) 4500 tr/min = 2250/60 = 37.5 cycles/s En 1 seconde – W_T = 37.5 x 553 = 20737.5 J soit P = 20737.5 / 736 = 28.2 CV	0.5
8) The real Cop will be lower since the real cycle is less reversible then the modeled one (pressure not homogeneous, not really adiabatic...) and the intake-exhaust cycle is consuming some of the power of the engine $W > 0$.	1

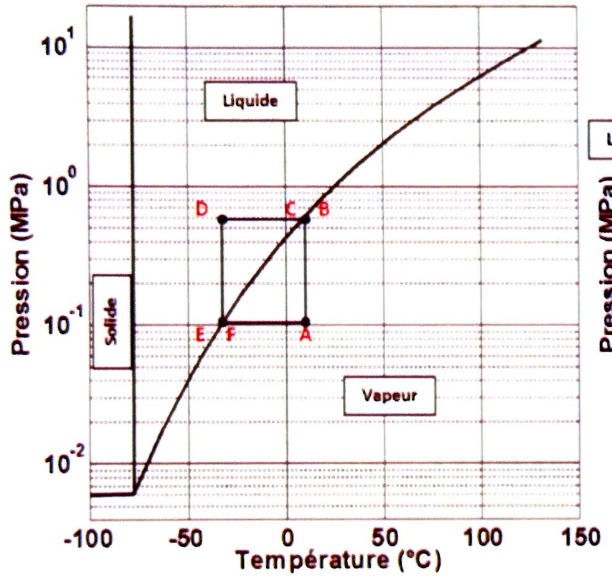
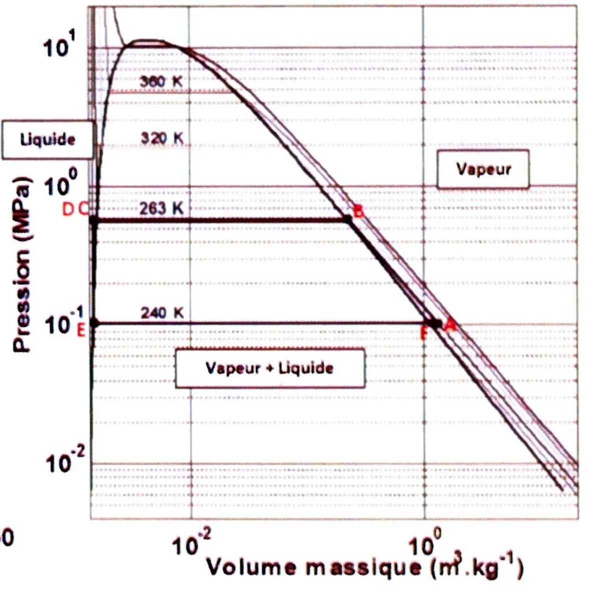
Influence of combustion (BC stage of the ABCDA cycle)	*2.5 points*
9) $C_8H_{18(g)} + 25/2\ O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)}$	0.5
10) 1 mole d'octane pour 12,5 moles d'O_2 et donc 12,5/0,2 = 62,5 moles d'air. A chaque injection de n moles de gaz, $n_{octane} = n/63,5 = 0,45$ mmol $x_{octane} = \frac{0,45}{28,3} = 0,016$. D'où masse injectée $m_{octane} = n_{octane} \times M_{octane} = 51$ mg ; V=m/ρ = 71μL	1
11) On brule à chaque explosion 51 mg, ce qui génère une chaleur	

Q_{BC}= 2278 J = $\frac{nR}{\gamma-1}$ $(T_C - T_B)$ (on approxime la quantité de gaz constante) $T_C = T_B + Q_{BC}\,\frac{\gamma-1}{nR}$ = 4729 K Valeurs anormalement élevées dues au caractère idéal de ce qui a été considéré ici, combustion totale, octane pur, pas de pertes de chaleur, valeur calculées pour des molécules diatomiques, alors que beaucoup sont plus complexes.	1

Exercice 2 ***(2 points)***

1) 1st law : $\Delta U = W + Q = W$ car adiabatique GP : $\Delta U = n\,\overline{C_V}\,(T-T_0)$ $W = -P_e\,(V-V_0)$ car $P_{ext} = P_e$ = cte Donc $n\,\overline{C_V}\,(T-T_0) = -P_eV + P_eV_0 = -nRT + (P_e/P_0)\,nRT_0$ Soit $(\overline{C_V}+R)\,T = [\,\overline{C_V} + R(P_e/P_0)]\,T_0$ D'où $T = T_0\,[\overline{C_V} + R(P_e/P_0)]\,/\,(\overline{C_V}+R)$ = 274 K	2

Exercice 3 ***(4 points)***

 	4 = 12× 0.25 *[Position of points]* 1 *[Physical state]*