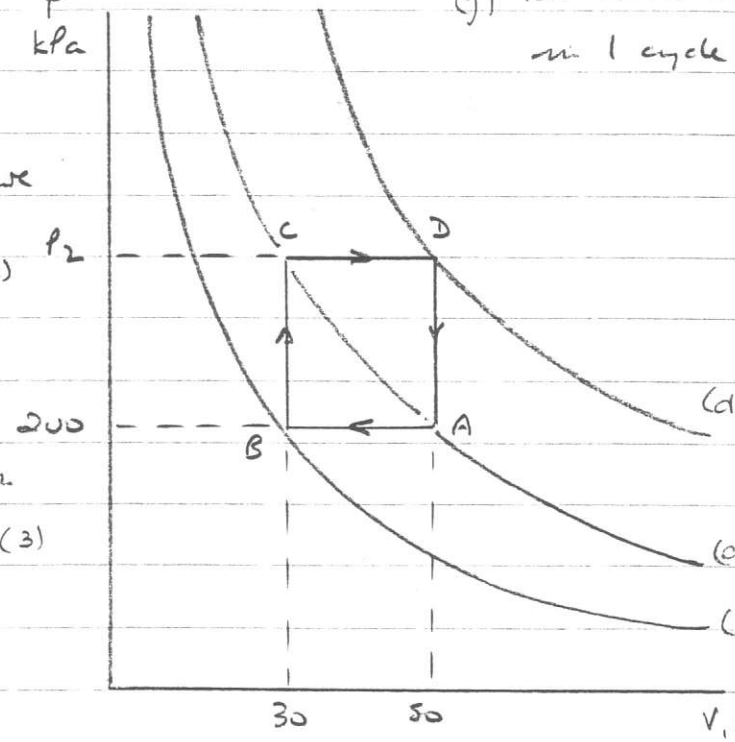
# Thermodynamics – The Heat Engine Cycle

A Physics

This is a PV diagram for 3.0 moles of gas. You can do the working out on this sheet.

$R = 8.3\ J\ mole^{-1}$

1




(c) pressure $P_2$ ? (2)

(e) work done on gas in compression + show on graph (3)

(g) net work done by gas in 1 cycle + draw it in (3)

(d) Temp $T_3$ ? (2)

(a) Temp $T_2$ ? (2)

(b) Temp $T_1$ ? (2)

(f) work done by gas expanding + show on graph (3)

out of ... (17)

2. Adiabatic change

A mass of gas at 250 kPa, 0.05 $m^3$ and 400 K is allowed to expand adiabatically to 8 kPa and 300 K.

(a) What is its new volume? (2)

(b) Draw the PV diagram, show the isotherms for 300 K and 400 K + show the adiabatic path – mark it A (4)

(c) The gas is returned to its initial state by isovolumetric heating (draw it in + mark B), and then by isothermal compression (draw it in + mark it C) {don't forget the arrows!} (4)

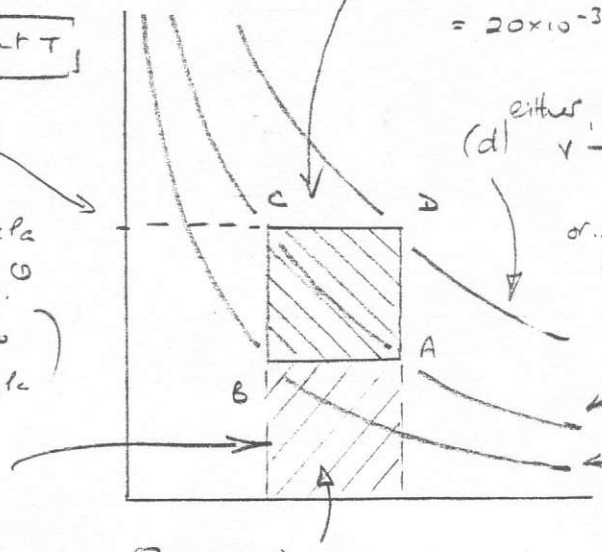
RN 3.99

# Thermodynamics – Heat Engine Cycle – answers

A Physics

remember 3 moles of gas !

(g) net work ... shaded ①
= area in ABCD ①
= $20\times10^{-3} \times 133\times10^{3} = \underline{2660\ J}$ ① (3)




constant T

(c) pressure $P_2$

use $P_1V_1 = P_2V_2$ ①

so $P_2 = P_1 V_1/V_2 = 200 \times 5/3$ kPa
$= \underline{333\ kPa}$ ①

(Since $V \to \frac{3}{5}V$ · so $P \to \frac{5}{3} \times 200$
$= 333$ kPa)

either, constant pressure $P_2$

(d) $V \to 5/3\ V$ so $T \to 5/3 \times T_2$

so $T_3 = 5/3 \times 401 = \underline{669\ k}$

or ... constant vol, $50\times10^{-3}\ m^3$

P goes $200 \to 333 = P \times 5/3$

so $T \to 5/3 \times 401 = \underline{669\ k}$ ①

(a) $PV = nRT$

so $T_2 = PV/nR$ ①
$= \underline{401\ k}$ (2)

(b) use $V_1/T_1 = V_2/T_2$ ①

$T_2 = \frac{V_2}{V_1} \times T_1 = \underline{241\ k}$ ① (2)

(Since $V \to \frac{3}{5}V$ · then $T \to \frac{3}{5}$ of ...

(e) work done in compression ...

shaded ///// ① = area shaded ///// ①
$= 20\times10^{-3} \times 200\times10^{3}$
$= \underline{4000\ J}$ ①

(f) work done expanding
= total area
//// + ////// ①
$= 20\times10^{-3} \times 333\times10^{3}$
$= \underline{6660\ J}$ ①

(Check ....
net work = expand − compress
2660 = 6660 − 4000

Total /17

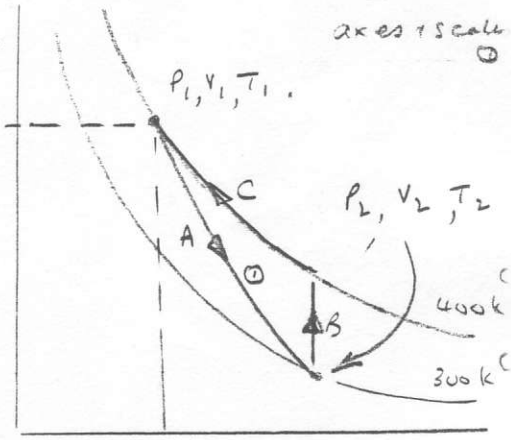
## 2. Adiabatic change

(a) now $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ①

so $V_2 = \frac{P_1}{P_2} \times \frac{T_2}{T_1} \times V_1$ keep it organised!

$= \frac{250\times10^{3}}{8\times10^{3}} \times \frac{300}{400} \times 0.05 = \underline{1.17\ m^3}$ ①

(b) Graph ...




(b) See → ... (4)

(c) isovolumetric – constant volume
vertical + arrow ①, up to 400k
isothermal ①
isothermal – follows 400 k line
any isothermal ① its 400 k arc ①

no arrow = −1 !

/10

TJN

4.99 marking .. Q.1 /17 Q.2 /10