1.

Assignment 5

Physics 9B Fall 2013

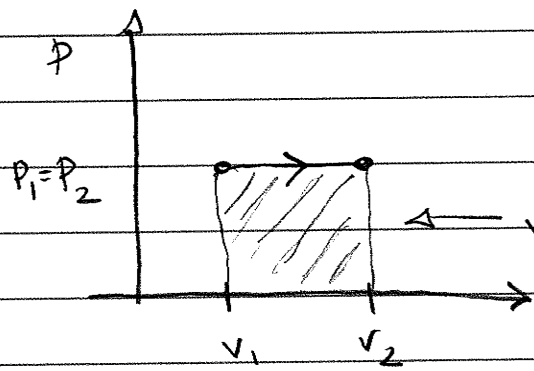
19 – 1, 3, 11, 19, 25, 29, 37, 41, 45

19-1 $PV = nRT$

initally $P_1 V_1 = 2(8.314)(300)$ ← 273 + 27

finally $P_2 V_2 = 2(8.314)(380)$ ← 273 + 107

We are also told $P_1 = P_2$ (constant pressure)



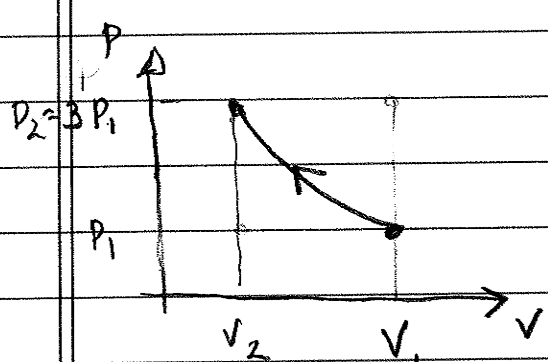
clearly $V_2 > V_1$ if $P_1 = P_2$ and $T_2 > T_1$

← work $= P_1(V_2 - V_1)$

subtract (use $P_2 = P_1$) $P_1(V_2 - V_1) = 2(8.314)(380 - 300) = \boxed{1330\ J}$

19-3 $PV = nRT$ $T = 65 + 273 = 338$ is fixed

$V_2 = 3V_1$



$W = \int_{V_1}^{V_2} P\,dV = nRT \int_{V_1}^{V_2} \frac{dV}{V} = nRT \ln \frac{V_2}{V_1}$

work done by gas

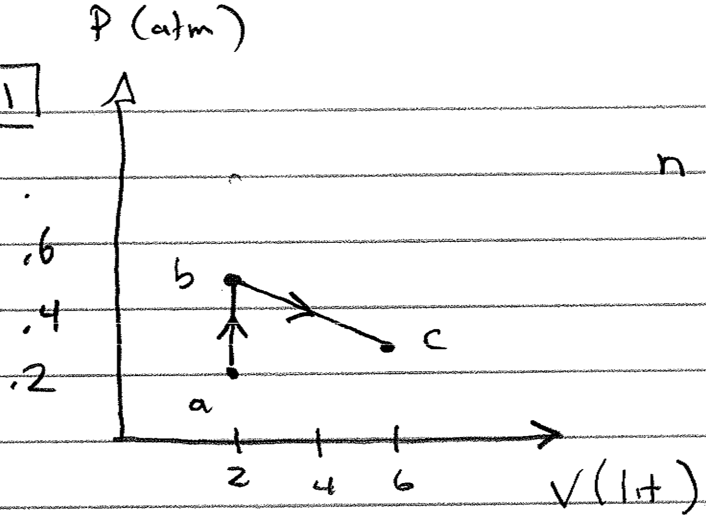
ideal gas law + T = const

$= 2(8.314)(338) \ln \frac{1}{3}$

$= \boxed{-6174\ J}$

2.

19-11



$n = 0.0175$ mole

$PV = nRT$

$T = PV/nR$

since n & R are constant, T is smallest when PV is smallest

at a) $PV = (.2)(2) = .4$ atm-lit

b) $PV = (.5)(2) = 1$ atm-lit

c) $PV = (.3)(6) = 1.8$ atm-lit

So T is lowest at a) $T_a = \frac{(.2)(1.01 \cdot 10^5)(2 \cdot 10^{-3})}{(.0175)(8.314)} = 278°K$

$W_{ab} = 0$ since V = const

$W_{bc} = \int P dV$ = area under curve ← trapezoid

$= \frac{1}{2}(.5 + .3)(6 - 2)$

$= 1.6$ atm-lit

$= 1.6\,(1.01 \cdot 10^5)(.001\ m^3) = 160$ J

First law $\Delta U = Q - W$

$= 215 - 160 = 55$ J

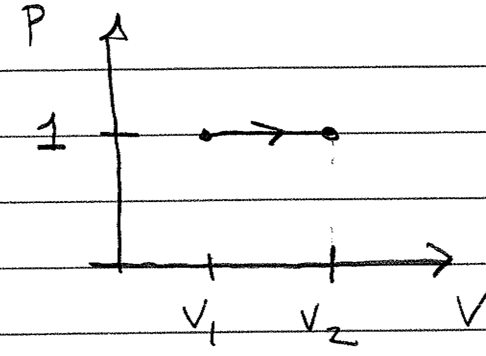
3.

19-19 $n = 0.25$ mole CO_2

$T = 27\,C = 300\,K$

$P = 1\,atm$ const

T increases to $127\,C = 400\,K$



$P_1 = P_2 = P$

$W = P(V_2 - V_1)$

$PV_1 = nRT_1 = .25(8.314)(300)$

$PV_2 = nRT_2 = .25(8.314)(400)$

$= .25(8.314)(400-300)$

$= 208\,J$

work done on <u>piston</u>

$U = nC_v\Delta T = (.25)(28.46)(100) = 712\,J$

for monatomic $\frac{3}{2}R$

diatomic $\frac{5}{2}R$

CO_2 28.46 J/mole°K

$U = Q - W \Rightarrow 712 = Q - 208$ $Q = 920\,J$

The calculations for PV_1 and PV_2 always give same #'s if n, T unchanged. Thus work is same.

19-25 $n = 3$ mole N_2

$Q = 1557$ J

a) $V =$ const $\Rightarrow W = 0$

$\Delta U = Q = 1557 = nC_V \Delta T$

$= 3(20.76)(\Delta T)$

$\Delta T = 25\ °K$

b) $P =$ const $\Rightarrow W \neq 0$

$Q = nC_p \Delta T$

$1557 = 3(29.07)\Delta T \qquad \Delta T = 17.9\ °K$

c) final U higher in a) because T higher

in b) some of heat went into work done by gas resulting in lower final T and lower final U

19-29 $P_1 = 1.5 \cdot 10^5$ Pa

$V_1 = .08\ m^3 \longrightarrow V_2 = .04\ m^3$

adiabatically

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ monatomic $\gamma = 5/3$

$(1.5 \cdot 10^5)(.08)^{5/3} = P_2 (.04)^{5/3} \qquad P_2 = 4.76 \cdot 10^5$ Pa

$W = \frac{1}{(\gamma - 1)}(P_1 V_1 - P_2 V_2) = \frac{1}{(2/3)}\left(1.5 \cdot 10^5 (.08) - 4.76 \cdot 10^5 (.04)\right)$

$= -10570$ J

5.

19-29 cont'd $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$T_2/T_1 = (V_1/V_2)^{\gamma-1} = (2)^{2/3} = 1.59$

gas is heated (T went up)

19-37 $n = 1$ mole

$V_2 = 1/3\, V_1$

$W_{on\,gas} = 600$ J

$C_p = 7/2\, R$

a) isothermal $\Rightarrow \Delta U = 0$ U depends only on T

$\Delta U = Q - W$

← work done by gas = −600 J

$0 = Q - (-600)$

$Q = -600$

← heat flowed out

b) isobaric (constant P)

$W = P\Delta V = nR\Delta T$ (isobaric) $\Delta T = \frac{W}{nR} = \frac{-600}{1(8.314)} = -72.2$ K

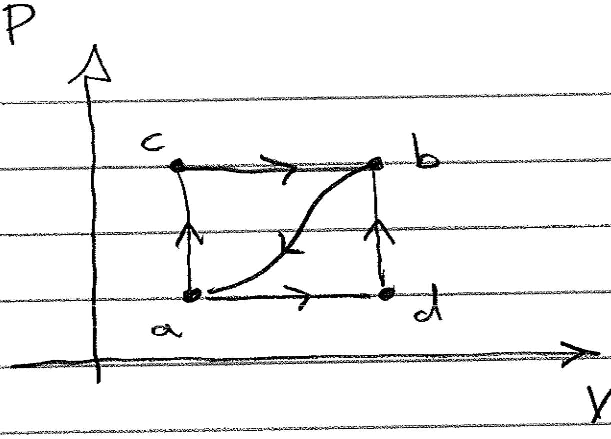
$C_v = C_p - R = \frac{5}{2}R = 20.78$

$U = nC_v\Delta T = 1(20.78)(-72.2) = -1500$ J

U decreases //

6.

[19-41]



$Q_{acb} = 90\ J$ into system

$W_{acb} = 60\ J$ done by system

a) $Q_{adb} = ?$ if $W_{adc} = 15\ J$

Remember U is indep of path.

$U_{acb} = Q_{acb} - W_{acb} = 90 - 60 = 30$

same $\Updownarrow$

$U_{adb} = Q_{adb} - W_{adb} = Q_{adb} - 15$

so $Q_{adb} = 45\ J$ into system

b) W_{ba} (curved path) $= -35\ J$ $(\Delta V < 0)$

$U_{ba} = -U_{ab} = -30 = Q_{ba} - W_{ba} = Q_{ba} + 35$

$Q_{ba} = -65\ J$ into system absorb

19-41 cont'd

c) $U_a = 0$ $U_d = 8$

We want Q_{ad} and Q_{db}.

We know $Q_{ad} + Q_{db} = Q_{adb} = 45\,J$

We also know $W_{adb} = W_{ad} + W_{db} = 15\,J$

↑ ∅ since volume fixed

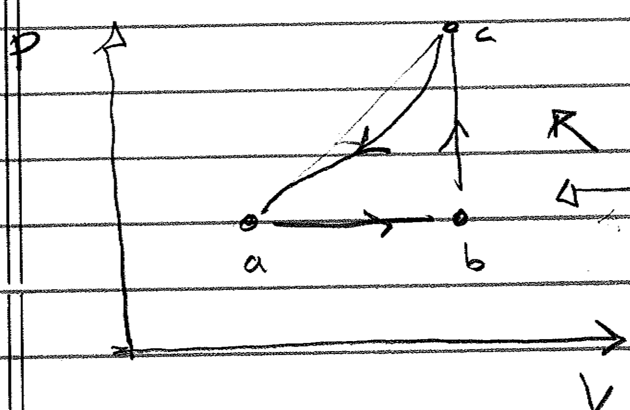
By first law $U_{ad} = Q_{ad} - W_{ad}$

$8 = Q_{ad} - 15$

$Q_{ad} = 23\,J$

→ $Q_{db} = 22\,J$

19-45 $n = 2$ moles monatomic



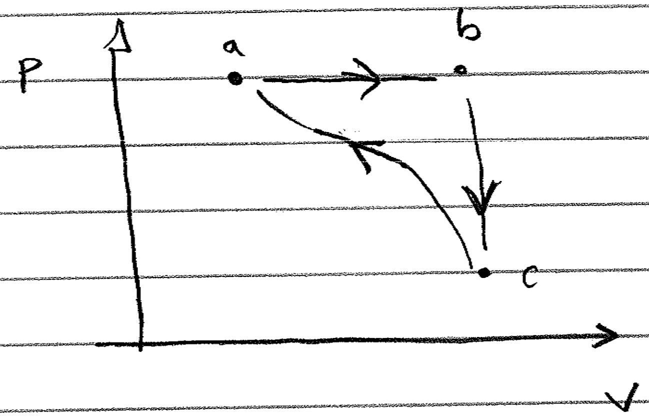
cycle $Q = -800$ (heat out)

$T_a = 200$ $T_b = 300$

← we are told a→b is constant P and b→c is constant V

$W_{ca} = ?$

19-45 Another possibility is this:



For whole cycle abca $Q = -800$ and $U = 0$ ← cyclic: return to same point (a)

So $0 = Q - W$

$= -800 - W$

$W = -800$ J

First picture (page 7) is correct since it has $W < 0$

$W_{TOT} = -800 = W_{ab} + W_{bc} + W_{ca}$

W_{bc}: 0 since $\Delta V = 0$

W_{ab}: $P\Delta V$ since P constant

$= nR\Delta T$ by ideal gas law

$= 2(8.314)(100) = 1660$ J

$-800 = 1660 + \emptyset + W_{ca}$

$W_{ca} = -2460$ J