Thermodynamics - Heating Gases (2) A Physics

formulas + data

$= W_{(J)} = P_{(Pa)} \Delta V_{(m^3)}$

$= \Delta H_p = n\, C_p\, \Delta T$

$= \Delta H_V = n\, C_V\, \Delta T_{(K)}$

J moles $J\,mol^{-1}K^{-1}$

$= C_p - C_V = R$

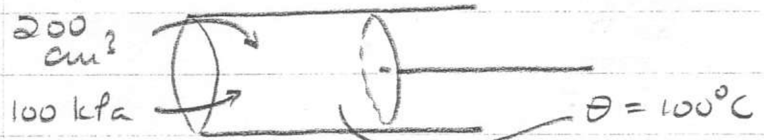
$= 1\ atm. = 1 \times 10^5\ Pa$

$= R = 8.3\ J\,mol^{-1}$

$= C_p$ air $= 30\ J\,mol^{-1}K^{-1}$

$= 1\ cm^3 = 1 \times 10^{-6}\ m^3$

= Stella = £1.80 $pint^{-1}$ (if you're lucky.)

1\. 

Gas in cylinder, as shown....

a) volume in m^3? (1)

b) Temp. in kelvin (1)

c) no. of moles? (2)

d) Gas heated to 200°C at constant volume. $C_V = 22\ J\,mol^{-1}K^{-1}$ Heat energy needed? (2)

e) What is value of C_p? (2)

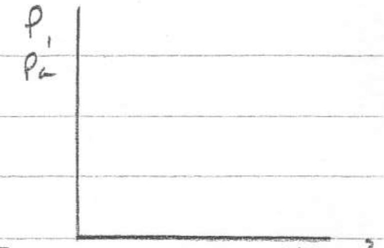
f) Gas heated to 200°C at constant pressure - heat energy needed? (2)

g) New gas volume at 200 °C and 100 kPa? (2)

h) Work done expanding? (2)

i) Comment on answers d) + f), and (h). (1)

j) Sketch the pV graph, and show the heating processes at constant volume, and constant pressure (4) [19]



2\. C_V is 900 $J\,kg^{-1}K^{-1}$ for a certain gas. (note: in kg.)

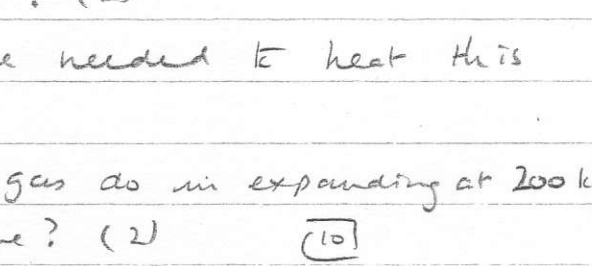
a) No. of moles in $1\ m^3$ at 100 kPa and 25°C? (2)

b) No. of moles in 1 kg if density is 1.5 kg/m^3 (2)

c) C_V for the gas in $J\,mole^{-1}K^{-1}$ (2)

d) C_p in $J\,mole^{-1}K^{-1}$ (2) [8]

3\. When the gas in the cylinder is heated to 127°C at constant volume, it requires 4 kJ.



a) How many moles are in the cylinder? (2)

b) What is the molar specific heat, C_V? (2)

c) How much heat energy would be needed to heat this gas at constant pressure? (2)

d) How much physical work would the gas do in expanding at 200 kPa? (2)

e) What would be the new gas volume? (2) [10]

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Q... 1 /19 2 /8 3 /10

Thermodynamics - Heating Gases (2) Answers — A Physics

1. a) Vol = $200 \times 10^{-6}\ m^3$ (1) (b) $T = 273 + 100 = 373\ K$ (1)

c) $PV = nRT$ (1) $\rightarrow n = PV/RT = 0.00646$ (1) moles (6.46×10^{-3})

d) use $\Delta H = n C_v \Delta T$ (1) $= 0.00646 \times 22 \times 100 = 14.2\ J$ (1)

e) recall $C_p - C_v = R$ so $C_p = C_v + R = 22 + 8.3 = 30.3$ (1) $J\ mole^{-1}\ K^{-1}$

f) Constant pressure .... use $\Delta H = n C_p \Delta T$ (1) $= 19.6\ J$ (1)

g) new gas vol.... use $V_1/T_1 = V_2/T_2 \rightarrow$ new $V_2 = V_1 \times \frac{T_2}{T_1} = 254 \times 10^{-6}\ m^3$ (2)

or $PV = nRT$ so $V_{new} = nRT/p = 0.00646 \times 8.3 \times 473 / 100 \times 10^3 = 254 \times 10^{-6}\ m^3$

h) work done expanding... $W = P\Delta V$ (1) $= 100 \times 10^3 \times 54 \times 10^{-6} = 5.4\ J$ (1)

i) Const. V... $\Delta H = 14.2\ J$

const P... $\Delta H = 19.6\ J$

extra energy = 5.4 J

= work done expanding

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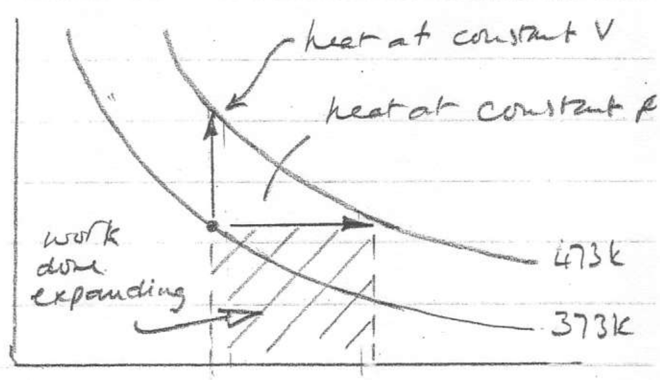

j) axes (1) 2 isotherms (1) ↑ (1) → (1)

2. a) $PV = nRT$ (1) $\rightarrow n = PV/RT$

$= 100 \times 10^3 \times 1 / 8.3 \times 298 = 40.4$ (1) moles

b) 40.4 moles in $1\ m^3$ = 1.5 kg

$\therefore 40.4 / 1.5 = 26.95 = 27.0$ moles in 1 kg of gas

c) $C_v = 900\ J\ kg^{-1}\ K^{-1} = 900\ J$ for 27.0 moles

8

so $C_v = 900/27 = 33.3\ J\ mole^{-1}\ K^{-1}$

d) $C_p - C_v = R$ for 1 mole ... so $C_p = R + C_v = 33.3 + 8.3 = 41.6\ J\ mol^{-1}\ K^{-1}$

3. a) no. moles $n = PV/RT = 200 \times 10^3 \times 20{,}000 \times 10^{-6} / 8.3 \times 300 = 16.1$ moles (1)

b) $\Delta Heat = n C_v \Delta T$ (1) $\rightarrow C_v = \Delta H / n \Delta T = 4000 / 16.1 \times 100 = 24.9$ (1) J/mole/K

c) $C_p - C_v = R$ (1) $\rightarrow C_p = C_v + R = 24.9 + 8.3 = 33.2$ (1) J/mole/K

so ΔH at constant pressure $= n C_p \Delta T$ (1) $= 16.1 \times 33.2 \times 100 = 5333\ J$ (1)

should be (4)!

d) physical work $W = \Delta H$ const. pressure $- \Delta H$ const. volume (1)

$= 5333 - 4000 = 1333\ J$ (1)

e) Use $W = P\Delta V \rightarrow \Delta V = W/p = 1333 / 100 \times 10^3 = 0.0133\ m^3$

so new volume $V_{new} = 0.02\ m^3 + 0.013 = 0.033\ m^3$ (2)

$= 20{,}000\ cm^3$

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Q.... 1/19 2/8 3/12 total