

Phys 344.

Assignment 2. Solutions.

Assignment #3.
2.1, 2.5b, 2.9

1.36.

$$V_i = 1 \text{ L} = 1.0 \times 10^{-3} \text{ m}^3$$

$$f = 5.$$

$$PV = NkT$$

$$= nRT$$

$$P_f = 7 \text{ atm} = 7.0 \times 10^5 \text{ Pa}$$

$$PV^\gamma = \text{const.}$$

$$P_i = 1 \text{ atm} = 1.0 \times 10^5 \text{ Pa}$$

$$\gamma = \frac{f+2}{f} = \frac{7}{5} = 1.4$$

$$T_i = \text{Room Temp} = 300 \text{ K}$$

a)

$$P_f V_f^\gamma = P_i V_i^\gamma$$

$$V_f = V_i \left(\frac{P_i}{P_f} \right)^{1/\gamma} = 1 \times 10^{-3} \times \left(\frac{1 \times 10^5}{7 \times 10^5} \right)^{5/7} = 2.5 \times 10^{-4} \text{ m}^3$$

$$= 0.25 \text{ L.}$$

b)

$$W = - \int P dV \quad P = \frac{P_i V_i^\gamma}{V^\gamma}$$

$$= - P_i V_i^\gamma \int_{V_i}^{V_f} V^{-\gamma} dV$$

$$= - \frac{P_i V_i^\gamma}{1-\gamma} \left(V_f^{1-\gamma} - V_i^{1-\gamma} \right)$$

$$= \frac{10^5 \times (10^{-3})^{1.4}}{1.4-1} \left[(2.5 \times 10^{-4})^{-0.4} - (10^{-3})^{-0.4} \right]$$

$$= 15.8 \times (27.59 - 15.85)$$

$$= 186 \text{ J}$$

$$\approx 190 \text{ J}$$

c). quasistatic adiabatic process.

$$PV^\gamma = \text{const.} \quad (\text{ideal gas: } PV = NkT)$$

$$NkT \cdot V^{\gamma-1} = \text{const.}$$

$$\therefore TV^{\gamma-1} = \text{const.} \quad \gamma-1 = \frac{f+2}{f} - 1 = \frac{f+2-f}{f} = \frac{2}{f}$$

$$\text{OR. } TV^{\frac{2}{f}} = \text{const.}$$

$$T_f V_f^{\frac{2}{f}} = T_i V_i^{\frac{2}{f}}$$

$$T_f = T_i \left(\frac{V_i}{V_f} \right)^{\frac{2}{f}}$$

$$= 300 \text{ K} \left(\frac{10^{-3}}{0.25 \times 10^{-3}} \right)^{\frac{2}{5}}$$

$$= 520 \text{ K}$$

1-38. When a bubble expands, it does work to outside, $\Delta U < 0$.

— bubble A expands adiabatically, the gas inside has to lower ^{its} temperature to do the ^{expansion} work. ($T \propto U$) ($Q=0$)

— bubble B. has a constant temperature which is higher than the temperature of bubble A. Therefore, Bubble B is larger.

1.41. Metal: $T_i = 100^\circ\text{C} = 373\text{ K}$. mass: m_M

$T_f = 24^\circ\text{C} = 297\text{ K}$.

Water: $T_i = 20^\circ\text{C} = 293\text{ K}$ mass: $m_W = 0.25\text{ kg}$

$T_f = 24^\circ\text{C} = 297\text{ K}$. Specific heat:

$c_W = 4.186 \times 10^3\text{ J/kg}$

a) $Q_W = m \cdot c_W \cdot (\Delta T)_W$

$= 0.25 \times 4.186 \times 10^3 \times (4) = 4186\text{ J}$

b) 4186 J . (Heat gained by water = heat loss in metal)

c) $C_M = \frac{Q}{\Delta T} = \frac{-4186}{-76} = 55\text{ J/K}$

d) $c_M = \frac{C_M}{m_M} = \frac{55}{0.1} = 550\text{ J/kg}$

i. 45. $w = xy$, $x = yz$. ($y = \frac{x}{z}$)

a). $w = x \cdot \frac{x}{z} = \frac{x^2}{z}$.

b). $\left(\frac{\partial w}{\partial x}\right)_y = y$.

$\left(\frac{\partial w}{\partial x}\right)_z = \frac{2x}{z}$.

c). $\left(\frac{\partial w}{\partial y}\right)_x = x$.

$\left(\frac{\partial w}{\partial y}\right)_z = 2yz$.

$w = y^2 z$.

$\left(\frac{\partial w}{\partial z}\right)_x = -\frac{x^2}{z^2}$.

$\left(\frac{\partial w}{\partial z}\right)_y = y^2$.

1.47.

Heat to remove from Tea:

use: $^{\circ}\text{C} \cdot \text{g}, \text{cal}$

$$(200 \times 1 \text{ cal/g}) (35^{\circ}\text{C}) = 7000 \text{ cal}.$$

Ice: mass = m . $c = 0.5 \text{ cal/g}^{\circ}\text{C}$

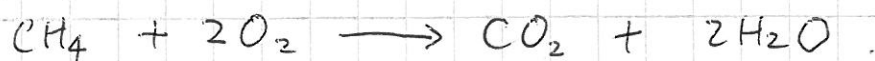
— warm up to 0°C from -15°C .

— melt at 0°C $80 = L$ (cal/g).

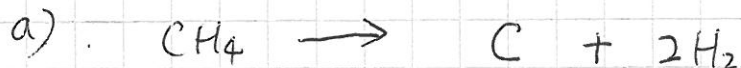
— warm up to 65°C (water)

$$m(0.5)(15) + m(80) + m(1 \text{ cal/g}^{\circ}\text{C})(65) = 7000.$$

Solve for $m = 46 \text{ g}$.

1.50. 1 mole of CH_4 :

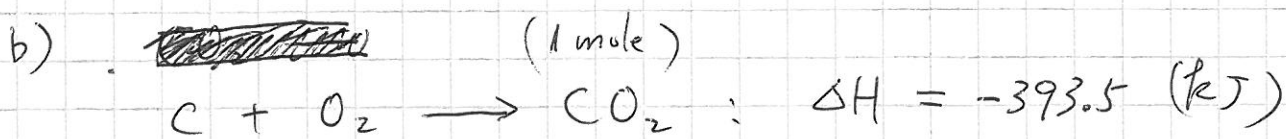
$$T = 298 \text{ K}, \quad P = 10^5 \text{ Pa (const)}$$



$$\Delta H \text{ for forming 1 mole of } \text{CH}_4 = -74.8 \text{ (KJ)}$$

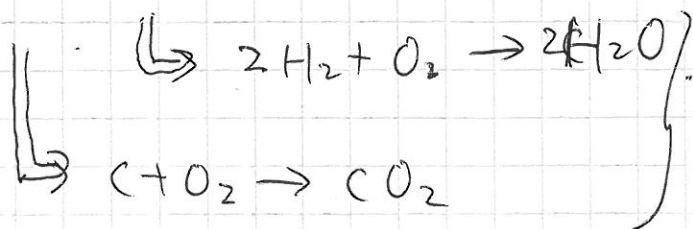
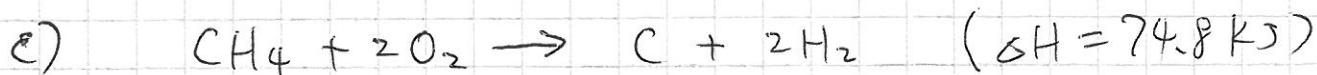
∴ ΔH for converting a mole of methane to C and H_2 gas:

$$\Delta H = 74.8 \text{ (KJ)}$$



∴ ΔH for forming ~~water of CO₂ and~~ 2 moles of water vapor:

$$\Delta H = \del{2 \times (-241.8)} = -483.6 \text{ (KJ)}$$



$$\Delta H = 74.8 - 393.5 - 483.6 = -802.3 \text{ KJ}$$

d) 802.3 KJ. (releasing heat)

e)

$$\Delta U = \Delta H - P\Delta V$$

$$\Delta V = 0 \quad \left\{ \begin{array}{l} V_i = \frac{n_i RT}{P_i} \\ V_f = \frac{n_f RT}{P_f} \end{array} \right.$$

$$n_i = 3.$$

1 mole of CH_4 2 moles of O_2 .

$$n_f = 3.$$

1 mole of CO_2 2 moles of H_2O gas.

$$\therefore \Delta U = \Delta H$$

$$= -802.3 \text{ kJ}.$$

However, if ~~the~~ the 2 moles of H_2O is liquid.

Then, for $2 \times (\text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O}_{\text{(liquid)}})$

$$\Delta H = 2 \times (-285.83) = -571.7 \text{ kJ}.$$

$$\text{Then Total } \Delta H = 74.8 - 393.5 - 571.7$$

$$= -890.4 \text{ kJ}$$

$$\Delta U = \Delta H - P\Delta V$$

$$V_f = \frac{n_f RT}{P_f}$$

(n_f = 1 now) CO_2 gas.

$$= \Delta H - (P_f V_f - P_i V_i)$$

$$= \Delta H - (RT - 3RT)$$

$$= \Delta H + 2RT = -890.4 + 2 \times 8.31 \times 298 = -885.4 \text{ kJ}.$$

f). 1 mole of CH_4 reacts with 2 moles of O_2 .

$\therefore$ ~~Total~~ Total mass of reactance - to produce $8.0 \times 10^5 \text{ J}$.

$$m = (12 + 4 + 2 \times 32) = 16 + 64 = 80 \text{ g} = 0.08 \text{ kg}.$$

Total mass of the sun / m :

$$\frac{2 \times 10^{30}}{0.08} = 2.5 \times 10^{31} \text{ moles of methane.}$$

(with ideal proportions with O_2)

Total energy it can give off.

$$2.5 \times 10^{31} \times 8 \times 10^5 = 2 \times 10^{37} \text{ J}.$$

Time it can last:

$$\frac{2 \times 10^{37}}{3.9 \times 10^{26}} = 5 \times 10^{10} \text{ sec} \approx 1600 \text{ years}.$$

That must NOT be the mechanism.