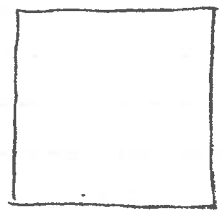
Homework #1 SOLUTIONS

1. Systems

(6 points)

a.



i rigid tank, as described is <u>closed</u>

ii ideal gas (one phase)

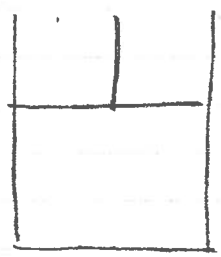
2 independent intensive properties

T + P (okay in 1-phase)

T + v

P + v

b.



i. closed (no mass enters or leaves)

ii. T + v

P + v

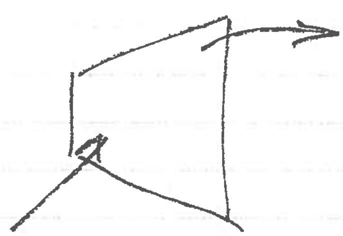
<u>NOT</u> T + P for 2-phase

T + X

P + X

v + X

c.



i. open (steam enters and leaves turbine)

ii. heat (Q)

work (W)

2. Easiest to consider entire piston-cylinder (valve) and rigid tank as one closed system when

(3 points)

$$F + P_{atm}(A) = 200\text{ kPa}(A) = 100\text{ kPa}(0.03\text{ m}^2) = 3\text{ kN}$$

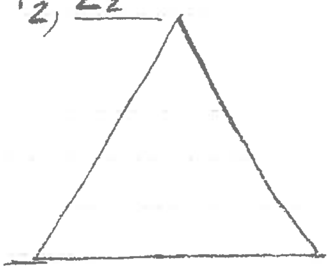
$W = F\Delta X$, where ΔX = displacement = -0.2 m (compression)

2. b. $W = -0.2\,m\,(3\,kN) = \boxed{-0.6\,kJ}$

(work done ON system)

c. $-W = \boxed{0.6\,kJ}$ = work done by surroundings

3. P_2, z_2



P_1, z_1

$P_1 > P_2$ due to weight of column of air between z_2 and z_1 for ρ_{air} and g constant

(3 points)

$$(P_2 - P_1)A = \rho g V$$

A = column area, V = column volume

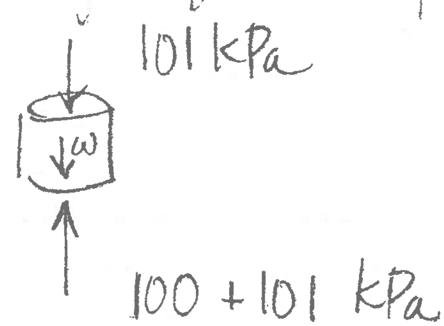
$$P_2 - P_1 = \rho g \frac{V}{A} = \rho g (z_2 - z_1)$$

check units: $\frac{N}{m^2} = \frac{kg}{m^3}\frac{m}{s^2}m = \frac{N}{m^2}$ ✓

$$z_2 - z_1 = \frac{0.93 - 0.78 \text{ bars}\left(10^5 \frac{N/m^2}{bar}\right)}{(1.2\,kg/m^3)(9.81\,m/s^2)}$$

$$z_2 - z_1 = \boxed{1{,}274\,m}$$

4. free body diagram on petcock



(2 points)

$$W_p + 101\ kPa\,(A_p) = 201\ kPa\,(A_p)$$

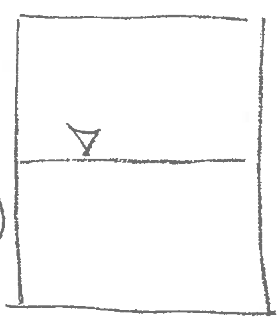
$$W_p = 100\ kPa\,(4\ mm^2)\left(\frac{10^{-6}\ m^2}{mm^2}\right) \cdot 10^3\ \frac{N}{kN}$$

$$= 0.4\ N$$

$$m_p = \frac{W_p}{g} = \frac{0.4\ kg\ m/s^2}{9.81\ m/s^2} \boxed{= 0.041\ kg}$$

$$= 0.041\ kg\left(10^3\ \frac{g}{kg}\right) = \boxed{41\ g}$$

5.



(3 points)

$V = 0.2\ m^3$, $m = 1.5\ kg$

liquid + vapor

$$V = m_g v_g + m_f v_f \; (= V_g + V_f)$$

where m_g = mass sat. vapor $\qquad m_f$ = mass sat. liquid

$v_g = 0.1943\ m^3/kg \qquad v_f = 1.127 \times 10^{-3}\ m^3/kg$

Also $m = m_g + m_f$

Substitute for $m_f = 1.5 - m_g$

$$0.2\ m^3 = 0.1943\ m_g + (1.5 - m_g)\,1.127 \times 10^{-3}\ (m^3)$$

$$0.1983\ m^3 = (0.1943 - 1.127 \times 10^{-3})\ m_g$$

5. $m_g = 1.027\ kg$

$m_f = 1.5 - 1.027 = 0.473kg$

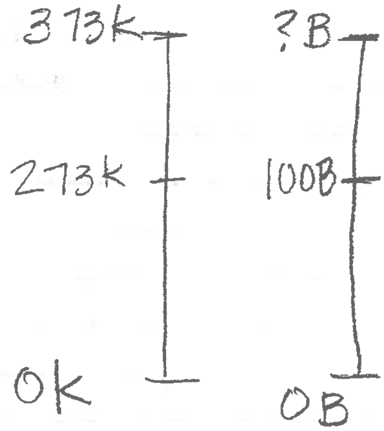
a. $V_g = m_g v_g = 1.03\,kg\,(0.1943)\,\frac{m^3}{kg}$ $\boxed{= 0.1995\ m^3}$

b. $\frac{m_f}{m} = \frac{0.473\ kg}{1.5\ kg}$ $\boxed{= 0.315 \text{ OR } 31.5\%}$

6. a. Buff scale is valid absolute Temp scale if zero is lowest value and degrees are equal in size.

(3 points)

b.



8

$100\ B = 273\ k$

$1\ B = \frac{273}{100}\ k = 2.73\ k$

$373\ k \left(\frac{1\ B}{2.73k}\right) = 137\ B$

Boiling point of water (1 atm P) $= \boxed{137\ B}$

c. $°C = K - 273$

$20°C = 293k$

$\frac{293k}{2.73}\left(\frac{B}{K}\right) = \boxed{107\ B}$ (room temp)