(i) GIVEN

object

» mass, $m = 10$ kg
» EN transfer $\dot{W}_{specific} = 0.147$ kJ/kg $= 147$ J/kg
» elevation decrease $\Delta h = -50$ m
» increase in velocity from $v_1 = 15$ m/s, $v_2 = 30$ m/s
» specific internal energy decrease $\Delta U_s = -5$ kJ/kg $= -5000$ J/kg
» $g = 9.7$ m/s^2

FIND

Heat transfer $\dot{Q}$

EQN

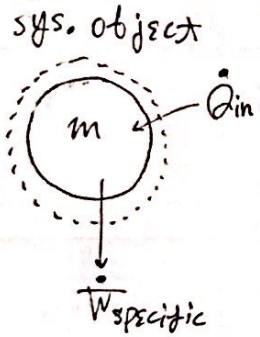
$$\left.\frac{dE}{dt}\right|_{sys} = \sum_{in} \dot{m}_{in}(h + ke + pe)_{in} - \sum_{out} \dot{m}_{out}(h + ke + pe)_{out} + \dot{Q} - \dot{W}$$

$PE = gz$, $KE = v^2/2$

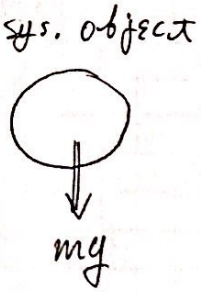
ASSUMP

* closed sys.
* no other EN loss
* Quasi equilibrium.

EFD



FBD



SOLN

$$\dot{Q} = m \cdot \Delta U_s + m \cdot \dot{W}_{specific} + \frac{1}{2} m (v_2^2 - v_1^2) + mg\Delta h$$

$$= (10\text{kg})\left(\frac{-5000\text{ J}}{\text{kg}}\right) + (10\text{kg})\left(\frac{147\text{ J}}{\text{kg}}\right) + \frac{1}{2}(10\text{kg})\left[(30^2 - 15^2)\left(\frac{\text{m}^2}{\text{s}^2}\right)\right]$$

$$+ (10\text{kg})\left(\frac{9.7\text{ m}}{\text{s}^2}\right)(-50\text{m})$$

$$= -50000\text{ J} + 1470\text{ J} + 3375\text{ J} - 4850\text{ J}$$

$$= -50005\text{ J}$$

$$\approx -50.0\text{ kJ}$$

$$\boxed{\dot{Q} = -50.0\text{ kJ}}$$

(ii) GIVEN

Rigid Tank
- >> 4 kg of CO(g) contained mass, m
- >> vol $\equiv V = 1\ m^3$
- >> paddle wheel $\dot{W} = -14$ W for $t = 1$ hr
- >> internal EN increase $\Delta U_{specific} = 10$ kJ/kg

FIND
(a) specific volume, $V_{specific,f}$ at final state in m^3/kg
(b) EN transfer by work in kJ
(c) EN transfer by heat, in kJ, and direction.

EQN

$$\frac{dm}{dt}_{sys} = \sum_{in} \dot{m}_{in} - \sum_{out} \dot{m}_{out}$$

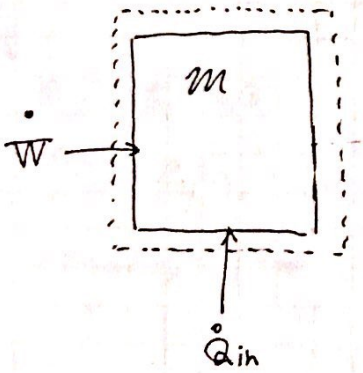
$$\Delta Q = \Delta U + \Delta W$$

$$PE = gz$$

ASSUMP closed sys.

Quasiequilibrium.
no overall KE & PE
closed sys.

FBD sys. rigid tank



SOLN

(a) the volume and mass of system does not change so

$$V_{specific} = (1\ m^3)/(4\ kg) = \boxed{0.250\ \frac{m^3}{kg}}$$

(b) work done to gas is $(-14\ W)(60 \times 60\ s) \times 10^{-3} = \boxed{-50.4\ kJ}$

(c) $\dot{Q} = \dot{U} + \dot{W}$

$$= \left(\frac{10\ kJ}{kg}\right)(4\ kg) + (-50.4\ kJ) = -10.4\ kJ$$

$$\boxed{\dot{Q}_{in} = -10.4\ kJ}$$