hi3002 The First Law of Thermo

= Energy conservation

heat unit Joule book kJ

1BTU = 1.055056 kJ

1kcal = 4.1868 kJ

Extensive variable: New

Internal energy U [kJ]

Specific internal $\frac{U}{m} = u$ $\frac{kJ}{kg}$

In the 2phase region

$u = u_f + x(u_g - u_f)$

u_f: sat liq

u_g: sat vap

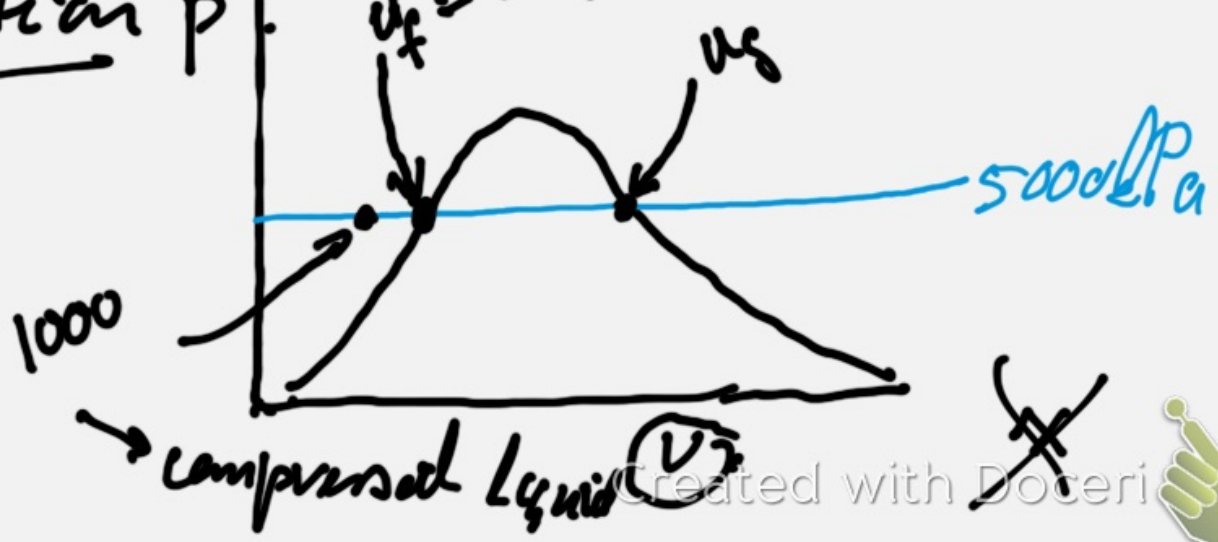
Chapter 3 type questions

example: H_2O 5000kPa = P

u = 1000 kJ/kg

Asked p, T, v, u_f & u_g

Solution p

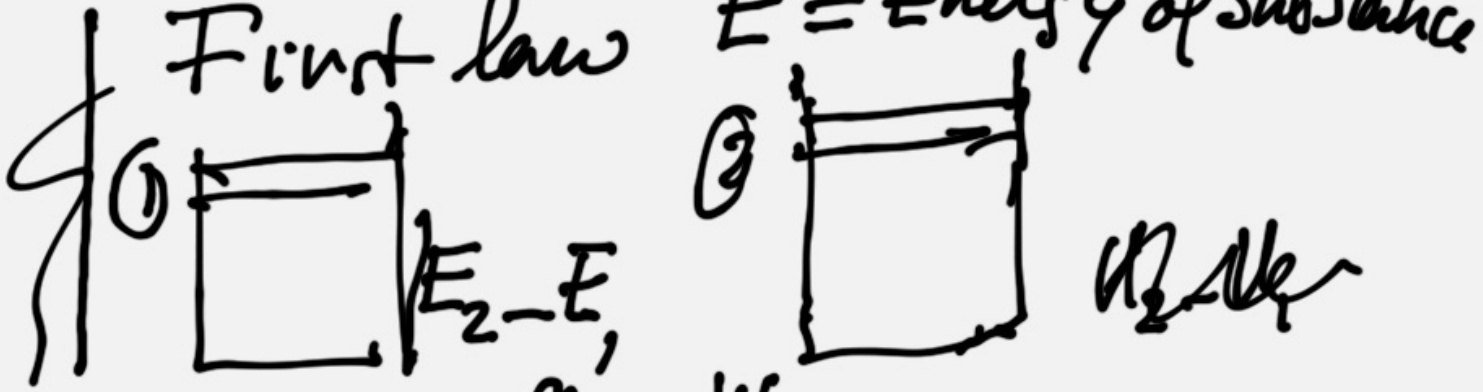


Interpolate in B·1·4

$T = 233\ ^{o}C \qquad v = 0.00123$

~~Example~~

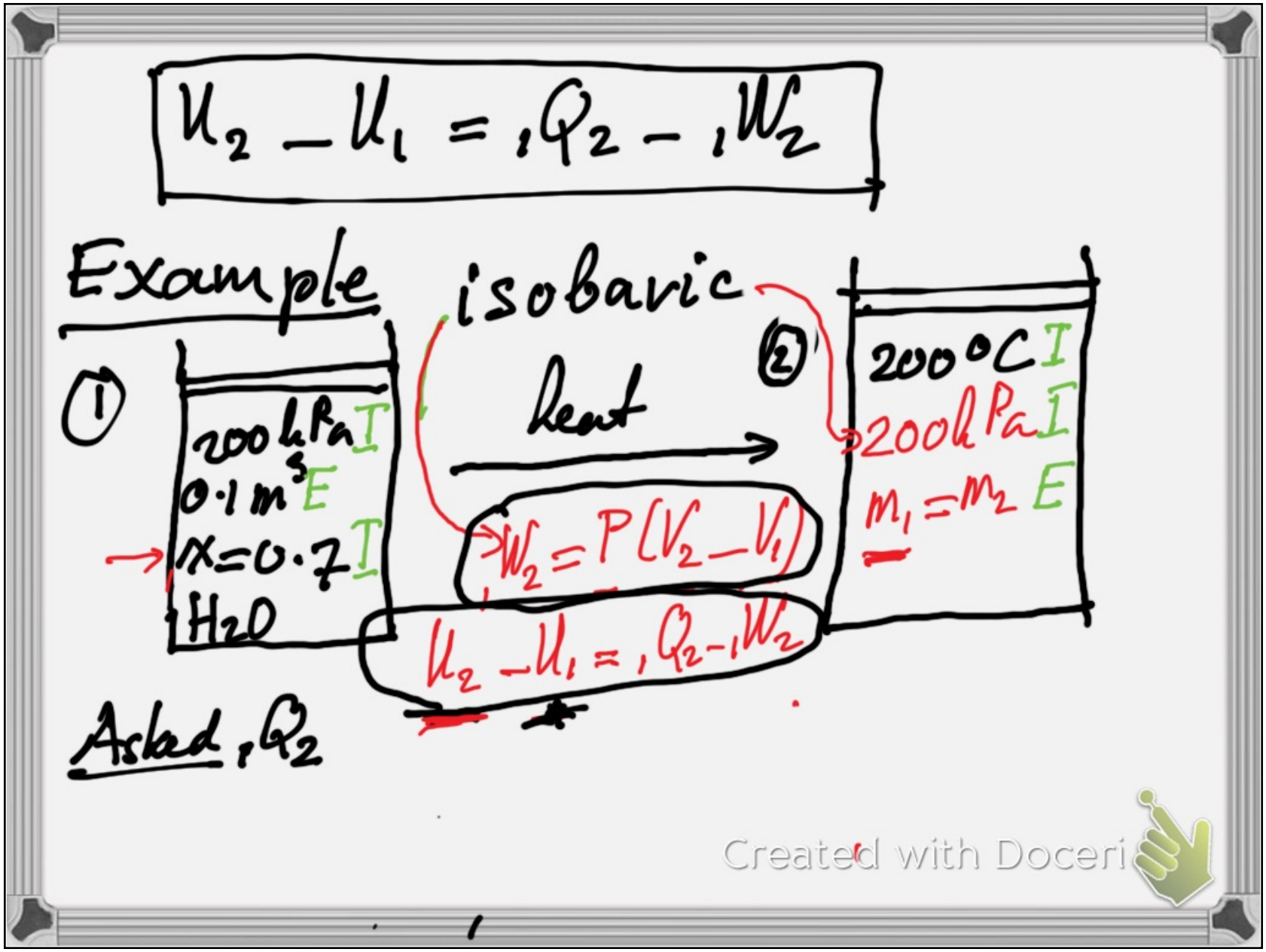
First law $\quad E$ = Energy of substance



$E_2 - E_1$

$= {}_1Q_2 - {}_1W_2$

$E = U + \cancel{mgz} + \cancel{\frac{1}{2} m\, vel^2}$


$U_2 - U_1 = {}_1Q_2 - {}_1W_2$
Example
isobaric
heat
1
200 kPa I
0.1 m³ E
x = 0.7 I
H2O
2
200°C I
200 kPa I
$m_1 = m_2$ E
$W_2 = P(V_2 - V_1)$
$U_2 - U_1 = {}_1Q_2 - {}_1W_2$
Asked $_1Q_2$
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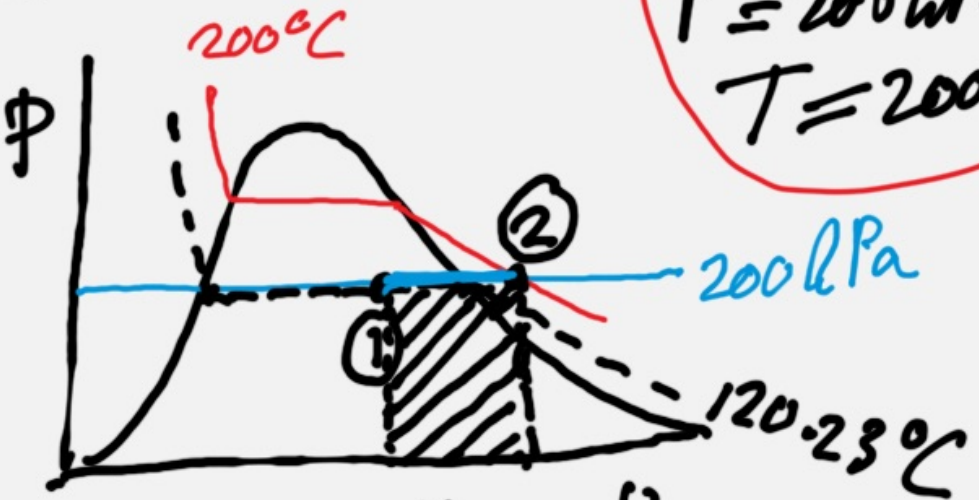
State ① : sat → B | 1.2

State ② :

$P = 200\ kPa$

$T = 200^{\circ}C$



① 200 kPa

$v = v_f + x\, v_{fg}$

$= (0.001061 + 0.7\ (0.88467))\ m^3/kg$

$= 0.62083\ m^3/kg$

$m = \frac{V_1}{v_1} = 0.1612\ kg$

$u_1 = u_f + x u_{fg} = (507.47 + 0.7\ 2025.02)\frac{kJ}{kg}$

$= 1921.98 \frac{kJ}{kg}$

$U_1 = m u_1 = 309.8\ kJ$

Next: ② SUV → B.1.3 200°C 200kPa

$v_2 = 1.08034 \frac{m^3}{kg}$ $u_2 = 2654.39 \frac{kJ}{kg}$

$V_2 = m v_2 = 0.1612kg\ 1.08034 \frac{m^3}{kg} = 0.17415 m^3$

$U_2 = m u_2 = 427.09\ kJ$

$$_1W_2 = P(V_2 - V_1) \qquad kPa\,m^3 = kJ$$

$$= 200\,kPa\,(0.17415 - 0.1)\,m^3$$

$$= 14.8\,kJ$$

$$_1Q_2 = U_2 - U_1 + {}_1W_2$$

$$= (427.09 - 309.8)\,kJ + 14.8\,kJ$$

$$= 133\,kJ$$

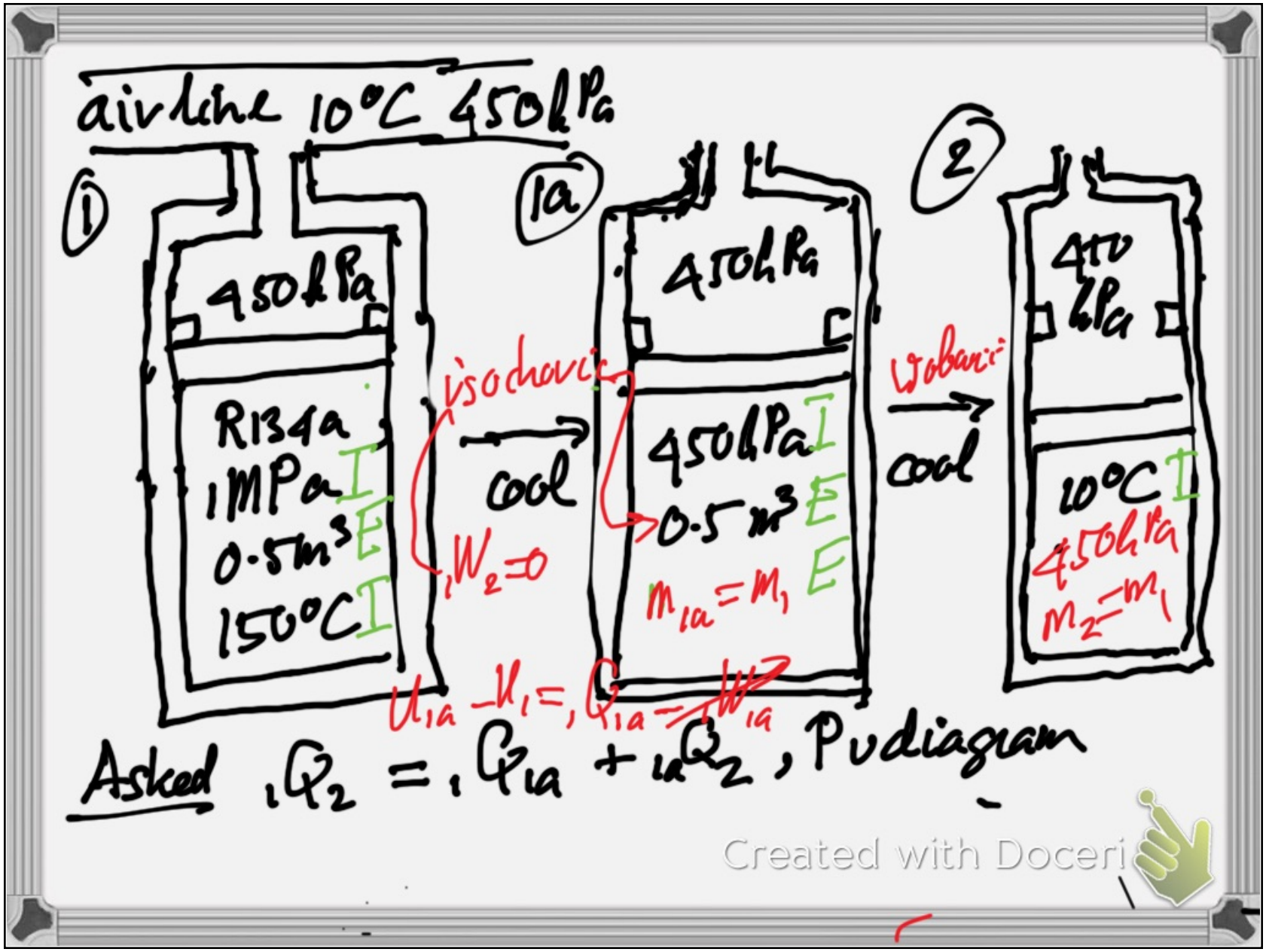
Quicker: isobaric only

$$U_2 - U_1 = {}_1Q_2 - (P_2V_2 - P_1V_1)$$

$${}_1Q_2 = \underbrace{(U_2 + P_2V_2)}_{H_2} - \underbrace{(U_1 + P_1V_1)}_{H_1}$$

$H = U + PV$ $\quad h = u + Pv$ tabulated

$${}_1Q_2 = mh_2 - mh_1$$


air/air 10°C 450kPa
1
450kPa
R134a
1MPa I
0.5m³ E
150°C I
isochoric
cool
1W2=0
1a
450kPa
450kPa I
0.5m³ E
m1a=m1 E
U1a - U1 = 1Q1a - 1W1a
isobaric
cool
2
450kPa
10°C I
450kPa
m2=m1
Asked 1Q2 = 1Q1a + 1aQ2, Pvdiagram
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