{Question 1E}

$$x+y^3=5$$
$$y=z^2-6$$
$$z=x^3-5+y$$

SOLUTION

Unit Settings: SI C kPa kJ mass deg

x = 1.844	y = 1.467	z = 2.733

No unit problems were detected.

{Question 2E}

Gz=1.4
Pr=0.8

Nu=1.29+(((0.1259+(0.0826/Pr^0.4))*Gz)/(1.2+0.1522*Gz^0.5)) {Nu = 1.509}

SOLUTION
Unit Settings: SI C kPa kJ mass deg
Gz = 1.4 ν = 1.509 Pr = 0.8

No unit problems were detected.

{Question 3E}

```
Vdot1=3.2[kg/m^3]
v1=1.4[m/sec]
Vdot2=1.4[kg/m^3]
v2=160[m/sec]
A1=200*convert(cm^2, m^2)

mdot=Vdot1*v1*A1 {Mass Flow Rate Through The Nozzle: mdot = 0.0896 kg/sec}
A2=mdot/Vdot2/v2*convert(m^2,cm^2) {Exit Area of The Nozzle: A2 = 4 cm^2}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

A1 = 0.02 [m^2]	A2 = 4	mdot = 0.0896
v1 = 1.4 [m/sec]	v2 = 160 [m/sec]	Vdot1 = 3.2 [kg/m^3]
Vdot2 = 1.4 [kg/m^3]		

No unit problems were detected.

{Question 4E}

```
P_1=4*convert(bar, kPa)
x_1=1
P_3=9*convert(bar, kPa)
x_3=0
n_isentropic=0.70
mdot=3[kg/min]
n_isentropic=(h_2s-h_1)/(h_2-h_1)

{Part a}
h_1=enthalpy(R134a,P=P_1,x=x_1)
s_1=entropy(R134a,P=P_1,x=x_1)

P_2=P_3
s_2s=s_1
h_2s=enthalpy(R134a,P=P_2,s=s_2s)

W=mdot*(h_2-h_1)/convert(min,sec) {Power of the Compressor: W = 1.2 kW}

{Part b}
h_3=enthalpy(R134a,P=P_3,x=x_3)
capacity=mdot*(h_1-h_3)/convert(min,sec)*convert(kW,tons) {Refrigerating Capacity: capacity = 0.343 tons}

{Part c}
COP=mdot*(h_1-h_4)/convert(min,sec)/W {Coefficient of Preformance: COP = 6.412}

{Part d}
T_1=temperature(R134a,P=P_1,x=x_1)
s_3=entropy(R134a,P=P_3,x=x_3)
T_4=T_1
s_4=s_3
P_4=P_1
T_2=temperature(R134a,P=P_2,h=h_2)
T_3=temperature(R134a,P=P_3,s=s_3)
s_2=entropy(R134a,P=P_2,h=h_2)
h_4=enthalpy(R134a,T=T_4,s=s_4)
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

capacity = 2.189 [tons]	COP = -9999	h_1 = 255.6 [kJ/kg]
h_2 = -9999 [kJ/kg]	h_{2s} = 272.4 [kJ/kg]	h_3 = 101.6 [kJ/kg]
h_4 = 99.52	mdot = 3 [kg/min]	$n_{isentropic}$ = 0.7
P_1 = 400 [kPa]	P_2 = 900 [kPa]	P_3 = 900 [kPa]
P_4 = 400	s_1 = 0.9269 [kJ/kg-K]	s_2 = -9999
s_{2s} = 0.9269 [kJ/kg-K]	s_3 = 0.3738	s_4 = 0.3738
T_1 = 8.91	T_2 = -9999	T_3 = 35.51
T_4 = 8.91	W = -9999 [kW]	x_1 = 1
x_3 = 0		

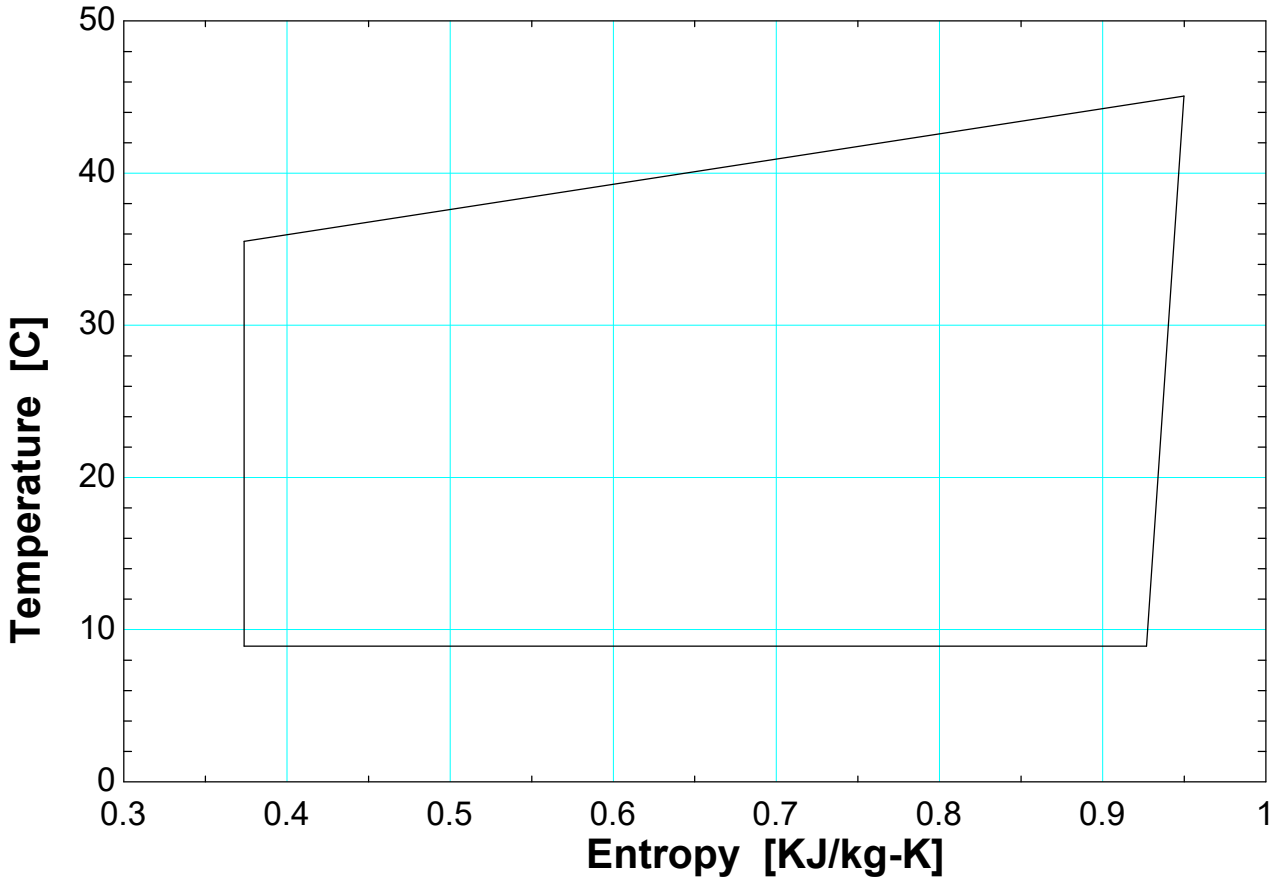
No unit problems were detected.

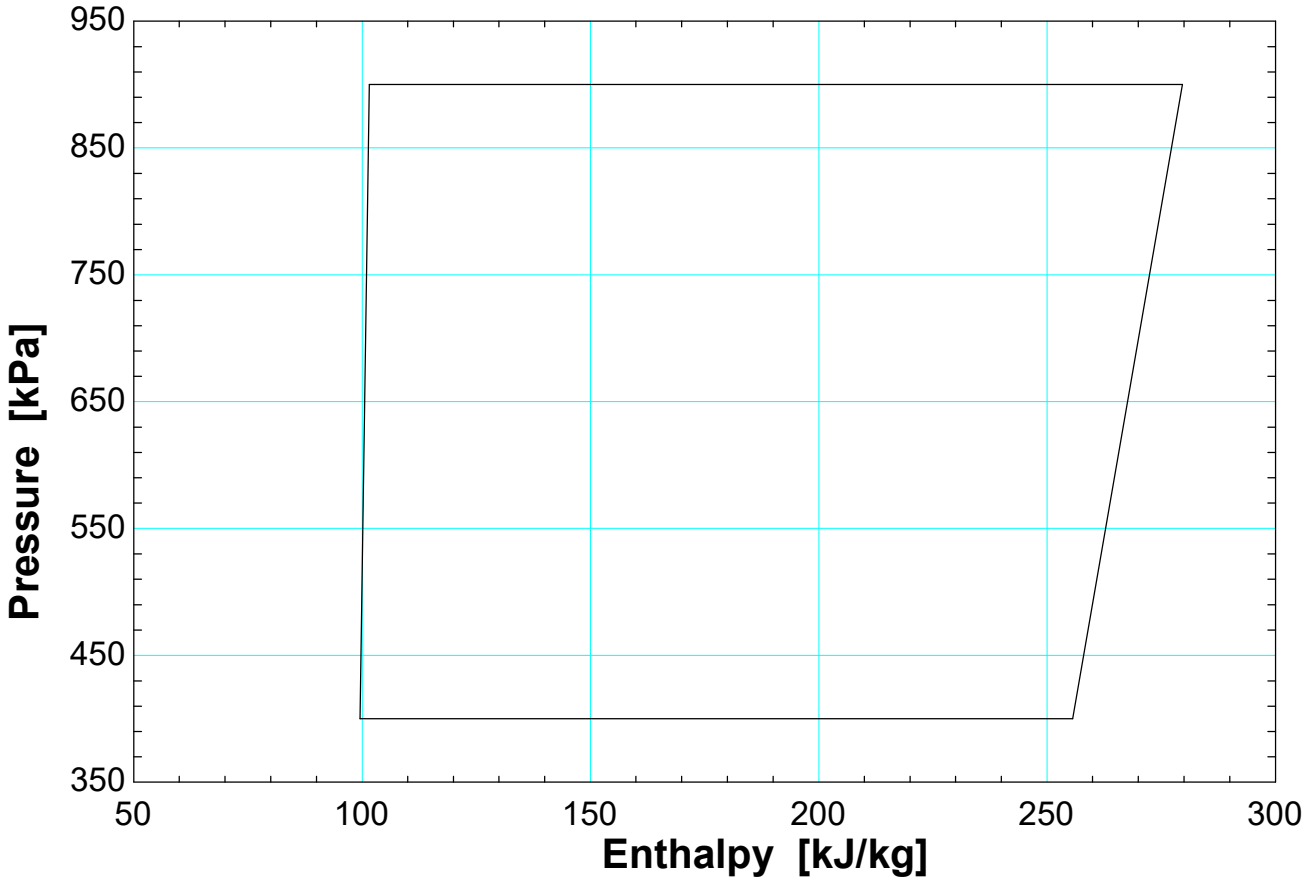
Lookup Table: Lookup 1

	Temperature [C]	Pressure [kPa]	Enthalpy [kJ/kg]	Entropy [KJ/kg-K]
Row 1	8.91	400	255.6	0.9269

Lookup Table: Lookup 1

	Temperature [C]	Pressure [kPa]	Enthalpy [kJ/kg]	Entropy [KJ/kg-K]
Row 2	45.05	900	279.6	0.9498
Row 3	35.51	900	101.6	0.3738
Row 4	8.91	400	99.52	0.3738
Row 5	8.91	400	255.6	0.9269





```
{Question 5E}

$UnitSystem ENG
T_1=35[F]
P_1=60[psi]
T_2=160[F]
P_2=170[psi]
T_3=80[F]
P_3=170[psi]
P_4=60[psi]

T_1water=55[F]
T_2water=40[F]
rho_water= 62.4[lb_m/ft^3] {assume density of water}

T_1air=70[F]
T_2air=100[F]
rho_air= 0.763[lb_m/ft^3] {assume density of air}

Qdot_out=3.8[tons]

{Part a}
h_1air=enthalpy(Air,T=T_1air)
h_2air=enthalpy(Air,T=T_2air)
h_2=enthalpy(R22,T=T_2,P=P_2)
h_3=enthalpy(R22,T=T_3,P=P_3)

Qdot_out*convert(tons, Btu/min)=mdot_air*(h_2air-h_1air)
Vdot_air=mdot_air/rho_air {Volumetric Flow Rate of the Heated Air: Vdot_air = 138.3 ft^3/min}

{Part b}
h_1=enthalpy(R22,T=T_1,P=P_1)
s_1=entropy(R22,T=T_1,P=P_1)
s_2s=s_1
P_2s=P_2
h_2s=enthalpy(R22,P=P_2s,s=s_2s)
efficiency_isentropic=(h_2s-h_1)/(h_2-h_1) {Turbines Isentropic Efficiency: efficiency_isentropic = 65.15%}

{Part c}
Qdot_out*convert(tons, Btu/min)=mdot_r22*(h_2-h_3)
Wdot_compressor=mdot_r22*(h_2-h_1)*convert(Btu/min, hp) {Compressor Power: Wdot_compressor = 3.397 hp}

{Part d}
h_4=h_3
T_4=temperature(R22,P=P_4,h=h_4)
COP=Qdot_out*convert(tons,hp)/Wdot_compressor {Coefficent of Preformance: COP = 5.276}

{Part e}
h_1water=enthalpy(Water,T=T_1water,x=0)
h_2water=enthalpy(Water,T=T_2water,x=0)
mdot_r22*(h_1-h_4)=mdot_water*(h_1water-h_2water)
Vdot_water=mdot_water/rho_water*convert(ft^3/min,gal/min) {Volumetric Flow Rate of Water: Vdot_water = 4.909 gal/min}

{Part f}
efficiency_carnot=1-(converttemp(F,R,T_1water)/converttemp(F,R,T_1air)) {Carnot Efficiency: efficiency_carnot = 2.832%}
```

SOLUTION

Unit Settings: Eng F psia mass deg

COP = 5.276	$efficiency_{carnot}$ = 0.02832
$efficiency_{isentropic}$ = 0.6515	h_1 = 175.4 [Btu/lb$_m$]

h_{1air} = 126.7 [Btu/lb$_m$]
h_2 = 193.1 [Btu/lb$_m$]
h_{2s} = 186.9 [Btu/lb$_m$]
h_3 = 99.96 [Btu/lb$_m$]
$mdot_{air}$ = 105.5 [lb$_m$/min]
$mdot_{water}$ = 40.95 [lb$_m$/min]
P_2 = 170 [psi]
P_3 = 170 [psi]
$Qdot_{out}$ = 3.8 [tons]
ρ_{water} = 62.4 [lb$_m$/ft^3]
s_{2s} = 0.4246 [Btu/lb$_m$-R]
T_{1air} = 70 [F]
T_2 = 160 [F]
T_{2water} = 40 [F]
T_4 = 21.96 [F]
$Vdot_{water}$ = 4.909 [gal/min]

h_{1water} = 23.07 [Btu/lb$_m$]
h_{2air} = 133.9 [Btu/lb$_m$]
h_{2water} = 8.032 [Btu/lb$_m$]
h_4 = 99.96 [Btu/lb$_m$]
$mdot_{r22}$ = 8.161 [lb$_m$/min]
P_1 = 60 [psi]
P_{2s} = 170 [psi]
P_4 = 60 [psi]
ρ_{air} = 0.763 [lb$_m$/ft^3]
s_1 = 0.4246 [Btu/lb$_m$-R]
T_1 = 35 [F]
T_{1water} = 55 [F]
T_{2air} = 100 [F]
T_3 = 80 [F]
$Vdot_{air}$ = 138.3 [ft^3/min]
$Wdot_{compressor}$ = 3.397 [hp]

No unit problems were detected.
EES suggested units (shown in purple) for P_2s s_1 s_2s T_4 .

```
{Question 6E}
T_1=5[C]
P_1=P_6

s_1=s_2
P_2=18*convert(bar,kPa)

T_3=45[C]
P_3=18*convert(bar,kPa)

P_4=18*convert(bar,kPa)

h_5=h_4
T_5=T_6

P_6=2*convert(bar,kPa)
x_6=1

mdot=8[kg/min]

{Part a}
(h_4-h_3)=(h_6-h_1)

h_1=enthalpy(Ammonia,T=T_1,P=P_1)
h_3=enthalpy(Ammonia,T=T_3,P=P_3)
h_6=enthalpy(Ammonia,P=P_6,x=x_6)
T_6=temperature(Ammonia,P=P_6,x=x_6)

capactiy=mdot*(h_6-h_5)*convert(kJ/min,tons) {Refrigeration Capacity: capacity = 40.94 tons}

{Part b}
s_1=entropy(Ammonia,T=T_1,P=P_1)
h_2=enthalpy(Ammonia,P=P_2,s=s_2)
Wdot_compressor=mdot*(h_2-h_1)/convert(min,sec) {Compressor Power: Wdot_compressor = 49.92 kW}

{Part c}
COP=capactiy*convert(tons, kW)/Wdot_compressor {Coefficient of Preformance: COP = 2.884}

{Part d}
P_5=pressure(Ammonia,T=T_5,h=h_5)
s_3=entropy(Ammonia,T=T_3,P=P_3)
s_4=entropy(Ammonia,P=P_4,h=h_4)
s_5=entropy(Ammonia,T=T_5,h=h_5)
s_6=entropy(Ammonia,P=P_6,x=x_6)
T_2=temperature(Ammonia,P=P_2,s=s_2)
T_4=temperature(Ammonia,P=P_4,h=h_4)
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

capactiy = 40.94 [tons]	COP = 2.884
h_1 = 1495 [kJ/kg]	h_2 = 1870 [kJ/kg]
h_3 = 415.5 [kJ/kg]	h_4 = 359.4 [kJ/kg]
h_5 = 359.4 [kJ/kg]	h_6 = 1439 [kJ/kg]
mdot = 8 [kg/min]	P_1 = 200 [kPa]
P_2 = 1800 [kPa]	P_3 = 1800 [kPa]
P_4 = 1800 [kPa]	P_5 = 200 [kPa]
P_6 = 200 [kPa]	s_1 = 6.097 [kJ/kg-k]
s_2 = 6.097 [kJ/kg-k]	s_3 = 1.722 [kJ/kg-K]
s_4 = 1.542 [kJ/kg-K]	s_5 = 1.64 [kJ/kg-K]

s_6 = 5.886 [kJ/kg-K]
T_2 = 181.8 [C]
T_4 = 33.6 [C]
T_6 = -18.85 [C]
x_6 = 1

T_1 = 5 [C]
T_3 = 45 [C]
T_5 = -18.85 [C]
$\dot{W}_{compressor}$ = 49.92 [kW]

No unit problems were detected.
EES suggested units (shown in purple) for h_2 h_5 P_5 s_3 s_4 s_5 .

Lookup Table: Lookup 1

	Temperature [C]	Pressure [kPa]	Entropy [kJ/kg-K]	Enthalpy [kJ/kg]
Row 1	5	200	6.097	1495
Row 2	181.8	1800	6.097	1870
Row 3	45	1800	1.722	415.5
Row 4	33.6	1800	1.542	359.4
Row 5	-18.85	200	1.64	359.4
Row 6	-18.85	200	5.886	1439
Row 7	5	200	6.097	1495