{Question 1.26}

```
g=9.81[m/s^2]
A=0.01[m^2]
m=50[kg]
P_atm=1[bar]

P=P_atm+((m*g)/A)*convert(Pa, bar) {Pressure: P = 1.491 bar}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

A = 0.01 [m^2]	g = 9.81 [m/s^2]	m = 50 [kg]
P = 1.491 [bar]	P_{atm} = 1 [bar]	

No unit problems were detected.

```
{Question 2.A-2}

{Part A}
P_1=14.7*convert(psi, kPa)
TSat_1=converttemp(C, F,t_sat(Water,P=P_1)) {Saturation Temperature: TSat_1 = 212 F}

{Part B}
P_2=24.58*convert(inHG, kPa)
TSat_2=converttemp(C, F,t_sat(Water,P=P_2)) {Saturation Temperature: TSat_2 = 202.2 F}

{Part C}
P_3=30[kPa]
TSat_3=converttemp(C, F, t_sat(Water,P=P_3)) {Saturation Temperature: TSat_3 = 156.4 F}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

P_1 = 101.4 [kPa]	P_2 = 83.24 [kPa]	P_3 = 30 [kPa]
$TSat_1$ = 212 [F]	$TSat_2$ = 202.2 [F]	$TSat_3$ = 156.4 [F]

No unit problems were detected.

{Question 3.21}

g=9.81[m/s^2]
P_atm=100[kPa]
A=0.01[m^2]
m_piston=50[kg]
m_water=0.1[kg]
T_water=100[C]

P_water=P_atm+((m_piston*g)/A)***convert**(Pa, kPa) {Pressure Water: P_water = 149.1 kPa}
V_water=m_water***volume**(***Water***, ***T***=T_water, ***P***=P_water)***convert**(m^3, cm^3) {Volume Water: V_water = 104.3 cm^3}

SOLUTION

Unit Settings: SI C kPa kJ mass deg

A = 0.01 [m^2]	g = 9.81 [m/s^2]	m_{piston} = 50 [kg]
m_{water} = 0.1 [kg]	P_{atm} = 100 [kPa]	P_{water} = 149.1 [kPa]
T_{water} = 100 [C]	V_{water} = 104.3 [cm^3]	

No unit problems were detected.

```
{Question 2.A-3}

V=8000*convert(cm^3, m^3)
x_1=0.05
T_1=140[C]

{Part A}
SV=volume(Steam, T=T_1, x=x_1) {Specific Volume: SV = 0.02645 m^3/kg}
P_1=pressure(Steam,T=T_1,v=SV) {Pressure: P_1 = 361.5 kPa}
TEST=quality(Steam,T=T_1, v=SV)

{Part B}
m_total=V/SV {Total Mass: m_total = 0.3024 kg}
m_water=m_total*(1-x_1) {Water Mass: m_water = 0.2873 kg}
m_vapor=m_total*x_1 {Vapor Mass: m_vapor = 0.01512 kg}

{Part C}
V_water=SV*m_water {Water Volume: V_water = 0.0076 m^3}
V_vapor=SV*m_vapor {Vapor Volume: V_vapor = 0.0004 m^3}

T_2=200[C]
{Part D}
P_2=pressure(Steam, T=T_2, v=SV) {Pressure: P_1 = 1,555 kPa}
x_2=quality(Steam, T=T_2, v=SV) {Quality: x_2 = 20.07 %}

{Part E}
m_water_2=V/SV*(1-x_2) {Water Mass: m_water_2 = 0.2418 kg}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

m_{total} = 0.3024 [kg]	m_{vapor} = 0.01512 [kg]	m_{water} = 0.2873 [kg]
$m_{water,2}$ = 0.2418 [kg]	P_1 = 361.5 [kPa]	P_2 = 1555 [kPa]
SV = 0.02645 [m^3/kg]	TEST = 0.05	T_1 = 140 [C]
T_2 = 200 [C]	V = 0.008 [m^3]	V_{vapor} = 0.0004 [m^3]
V_{water} = 0.0076 [m^3]	x_1 = 0.05	x_2 = 0.2007

No unit problems were detected.

{Question 4.007}

```
P_1=10[bar]
T_1=20[C]
P_2=3.0[bar]

h_1=enthalpy(Ammonia, P=P_1*convert(bar, kPa), T=T_1)
h_2=h_1

T_2=temperature(Ammonia, P=P_2*convert(bar, kPa), h=h_2) {Temperature: T_2 = -9.231C}
x_2=quality(Ammonia,P=P_2*convert(bar, kPa), h=h_2) {Quality: x_2 = 10.54 %}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

h_1 = 293.9 [kJ/kg]	h_2 = 293.9 [kJ/kg]	P_1 = 10 [bar]
P_2 = 3 [bar]	T_1 = 20 [C]	T_2 = -9.231 [C]
x_2 = 0.1054		

No unit problems were detected.

EES suggested units (shown in purple) for h_2 .

```
{Question 4.75}

P_3=5[bar]
x_3=0.20
P_4=5[bar]
T_4=20[C]

P_1=1[bar]
T_1=305[K]
AV_air=50[m^3/min]
P_2=0.95[bar]
T_2=295[K]

{Part A}
{Use first law equation to find mass flow rate of the refrigerant. We can neglect heat loss, work, kinetic energy, and potential energy}
 0=mdot_air*(h_1-h_2)+mdot_ref*(h_3-h_4)
mdot_air=AV_air*P_1*convert(bar,kPa)/(R#/molarmass(Air))/T_1
h_1=enthalpy(Air, T=converttemp(K,C,T_1))
h_2=enthalpy(Air, T=converttemp(K,C,T_2))
h_3=enthalpy(R134a, P=P_3*convert(bar,kPa), x=x_3)
h_4=enthalpy(R134a, T=T_4, P=P_4*convert(bar,kPa))
{Solving the The first law equation we find mdot_ref}
{Mass Flow Rate of Refrigerant: mdot_ref = 3.752 kg/min}

{Part B}
{Find heat transfer using first law of only the refrigerant. We can neglect work, kinetic energy, and potential energy}
 0=Qdot+mdot_ref*(h_3-h_4)
{Solving the The first law equation we find Qdot}
{Heat Transfer: Qdot = 573.8 kJ/min}
kJ=0
min=1
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

AV_{air} = 50 [m^3/min]	h_1 = 305.5 [kJ/kg]	h_2 = 295.4 [kJ/kg]
h_3 = 110.5 [kJ/kg]	h_4 = 263.5 [kJ/kg]	kJ = 0
$mdot_{air}$ = 57.11 [kg/min]	$mdot_{ref}$ = 3.752 [kg/min]	min = 1
P_1 = 1 [bar]	P_2 = 0.95 [bar]	P_3 = 5 [bar]
P_4 = 5 [bar]	Qdot = 573.8 [kJ/min]	T_1 = 305 [K]
T_2 = 295 [K]	T_4 = 20 [C]	x_3 = 0.2

No unit problems were detected.

EES suggested units (shown in purple) for h_1 h_2 h_3 h_4 .

```
{Question 4.009}

$UnitSystem ENG
T_1=40[F]
P_1=80[psi]
T_2=160[F]
P_2=200[psi]
T_3=90[F]
P_3=200[psi]

T_air_1=1[F]
P_air_1=14.7[psi]
Vdot_air=1[ft^3/min] {Vdot[ft^3/min] = VA[ft^3/min]}
T_air_2=110[F]

{Part A}
{Use first law equation to solve for Vdot_ref. We are observing the condensor so we can neglect heat transfer, work, kinetic energy and potential energy}
0=mdot_air*(h_air_1-h_air_2)+mdot_ref*(h_2-h_3)
{Alternate Method => mdot_air*cp(Air,T=T_air_1)*(converttemp(F,R,T_air_2)-converttemp(F,R,T_air_1))=mdot_ref*(h_2-h_3)}

{We need mdot_air in order to find mdot_ref, mdot_air = VA*rho, so we need to find density}
mdot_air=Vdot_air*density(Air, T=T_air_1, P=P_air_1)
h_air_1=enthalpy(Air, T=T_air_1)
h_air_2=enthalpy(Air, T=T_air_2)
h_2=enthalpy(R22, T=T_2, P=P_2)
h_3=enthalpy(R22, T=T_3, P=P_3)
{Solving the first law equation with the values we gathered we can calculate mdot_ref}
{Mass Flow Rate of Refrigerant: mdot_ref = 0.02531 lb/min}

{Part B}
{To find the work of the compressor we need to use the first law equation for only the refrigerant between states 1 and 2. We neglect heat loss, kinetic energy, and potential energy. WE DO NOT NEGLECT WORK}
0=Wdot+(mdot_ref*(h_1-h_2)*convert(Btu/min, hp))
h_1=enthalpy(R22, T=T_1, P=P_1)
{Solve the first law equation to find work}
{Compressor Power: Wdot = 0.01012 hp}
```

SOLUTION

Unit Settings: Eng F psia mass deg

h_1 = 175 [Btu/lb$_m$]	h_2 = 192 [Btu/lb$_m$]
h_3 = 103 [Btu/lb$_m$]	$h_{air,1}$ = 110.1 [Btu/lb$_m$]
$h_{air,2}$ = 136.3 [Btu/lb$_m$]	$mdot_{air}$ = 0.08613 [lb$_m$/min]
$mdot_{ref}$ = 0.02531 [lb$_m$/min]	P_1 = 80 [psi]
P_2 = 200 [psi]	P_3 = 200 [psi]
$P_{air,1}$ = 14.7 [psi]	T_1 = 40 [F]
T_2 = 160 [F]	T_3 = 90 [F]
$T_{air,1}$ = 1 [F]	$T_{air,2}$ = 110 [F]
$Vdot_{air}$ = 1 [ft^3/min]	Wdot = 0.01012 [hp]

No unit problems were detected.

{Problem 6.77}

```
Qdot_hot=15[kW]
Wdot_cycle=3.2[kW]
T_inside=22[C]
T_outside=-22[C]
```

{Energy Rate Balance Equation}

```
0=Qdot_hot+Qdot_cold-Wdot_cycle
```

{Entropy Rate Balanace Equation}

```
0=Qdot_hot/T_inside+Qdot_cold/T_outside+sigmadot
```

{Sigma-dot: sigmadot = -1.218 kW/C}

{Because Sigma-dot is negative the manufactures claims are false}

SOLUTION

Unit Settings: Eng F psia mass deg

$Qdot_{cold}$ = -11.8 [kW]	$Qdot_{hot}$ = 15 [kW]	sigmadot = -1.218 [kW/C]
T_{inside} = 22 [C]	$T_{outside}$ = -22 [C]	$Wdot_{cycle}$ = 3.2 [kW]

No unit problems were detected.

{Question 6.145}

T_1=290[K]
P_1=100[kPa]
P_2=330[kPa]

effiiceincy=0.903
effiiceincy=W_s/W
W_s=h_2s-h_1
W=h_2-h_1

h_1=**enthalpy**(***Air***, ***T***=**converttemp**(K,C,T_1))
s_1=**entropy**(***Air***, ***T***=converttemp(K,C,T_1), ***P***=P_1)
s_1=s_2s
h_2s=**enthalpy**(***Air***, ***P***=P_2, ***s***=s_2s)

{Using the isentropic efficeincy equation it is possible to find h_2 and then W}
{Work Input: W = 131.1 kJ/kg}

{Alternatively, you can solve this problem using the equation P_2/P_1=P_r2/P_r1, where P_r represents Relative Pressure which can be found on most thermodynamic property tables for ideal gasses}

SOLUTION

Unit Settings: SI C kPa kJ mass deg

effiiceincy = 0.903	h_1 = 290.4 [kJ/kg]	h_2 = 421.5 [kJ/kg]
h_{2s} = 408.8 [kJ/kg]	P_1 = 100 [kPa]	P_2 = 330 [kPa]
s_1 = 5.672 [kJ/kg-K]	s_{2s} = 5.672 [kJ/kg-K]	T_1 = 290 [K]
W = 131.1 [kJ/kg]	W_s = 118.4 [kJ/kg]	

No unit problems were detected.
EES suggested units (shown in purple) for h_1 h_2 h_2s s_1 s_2s .

{Problem 6.007}

```
mdot=1.2[kg/s]
T_1=50[C]
P_1=1.5*convert(MPa, kPa)
P_2=15*convert(MPa, kPa)
W_actual=21[kW]

W_reversible=mdot*v*(P_2-P_1) {Work Required by a Reversible Pump: W_reversible = 16.39 kW}

v=volume(Water,T=T_1,P=P_1)

n=W_reversible/W_actual {Isentropic Efficiency: n = 78.03%}
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

mdot = 1.2 [kg/s]	n = 0.7803	P_1 = 1500 [kPa]
P_2 = 15000 [kPa]	T_1 = 50 [C]	v = 0.001011 [m^3/kg]
W_{actual} = 21 [kW]	$W_{reversible}$ = 16.39 [kW]	

No unit problems were detected.

EES suggested units (shown in purple) for v .