"Scenario 10 - constant pressure then constant volume heat addition"

F$ = 'Steam_IAPWS' "water"

"Initial state - case A - subcooled liquid"

PA[1] = 101.325[kPa] "initial pressure same as external"
TA[1] = 25[C] "initial temperature inside and outside"
vol[1] = 1e-3[m3] "1 liter volume"

vA[1] = **volume**(F$, ***T***=TA[1], ***P***=PA[1]) "specific volume at state 1"
hA[1] = **enthalpy**(F$, ***T***=TA[1], ***P***=PA[1]) "specific enthalpy at state 1"
uA[1] = **intenergy**(F$, ***T***=TA[1], ***P***=PA[1]) "specific internal energy at state 1"
sA[1] = **entropy**(F$, ***T***=TA[1], ***P***=PA[1]) "specific entropy at state 1"
mass_A = vol[1]/vA[1] "mass of H2O"

"Add heat - go to state 2A the pressure is constant until vol[2]"
vol[2] = 2e-3[m3] "final volume"
Q = 1[kW] "rate of adding heat"

"state 2A - end of constant pressure"
PA[2] = PA[1] "constant pressure"
vA[2]=vol[2]/mass_A "specific volume at state 2"
TA[2]=**temperature**(F$,***u***=uA[2], ***P***=PA[2]) "temperature at state 2"
hA[2] = **enthalpy**(F$, ***u***=uA[2], ***P***=PA[2]) "specific enthalpy at state 2"
uA[2] = **intenergy**(F$,***v***=vA[2], ***P***=PA[2]) "internal energy at state 2"
sA[2] = **entropy**(F$, ***u***=uA[2], ***P***=PA[2]) "specific entropy at state 2"

uA[2] = uA[1]+Q*time12/mass_A-PA[1]*(vA[2]-vA[1]) "determine internal energy from 1st law"

"state 3A - final state of constant volume"
P[3]=1000[kPa] "final pressure"
PA[3]=P[3] "pressure at state 3"
vA[3]=vA[2] "constant volume"
uA[3] = uA[2]+Q*time23/mass_A "determine internal energy from 1st law"
uA[3] = **intenergy**(F$,***v***=vA[3], ***P***=PA[3]) "internal energy at state 3"
hA[3] = **enthalpy**(F$, ***P***=PA[3], ***v***=vA[3]) "specific enthalpy at state 3"
sA[3] = **entropy**(F$, ***P***=PA[3], ***v***=vA[3]) "specific entropy at state 3"
TA[3] = **temperature**(F$, ***P***=PA[3], ***v***=vA[3]) "temperature at state 3"

"initial state - case B - two phase"
PB[1] = 101.325[kPa] "pressure at state 1"
xB[1] = 0.1 "quality at state 1B"
TB[1] =**temperature**(F$, ***P***=PB[1], ***x***=xB[1]) "temperature at state 1"
vB[1] = **volume**(F$, ***T***=TB[1], ***x***=xB[1]) "specific volume at state 1"
hB[1] = **enthalpy**(F$, ***T***=TB[1], ***x***=xB[1]) "specific enthalpy at state 1"
uB[1] = **intenergy**(F$, ***T***=TB[1], ***x***=xB[1]) "specific internal energy at state 1"
sB[1] = **entropy**(F$, ***T***=TB[1], ***x***=xB[1]) "specific entropy at state 1"
mass_B = vol[1]/vB[1] "mass of H2O"

"state 2B - end of constant pressure"
PB[2] = PB[1] "constant pressure"
vB[2]=vol[2]/mass_B "specific volume at state 2"
TB[2]=**temperature**(F$,***u***=uB[2], ***P***=PB[2]) "temperature at state 2"
hB[2] = **enthalpy**(F$, ***u***=uB[2], ***P***=PB[2]) "specific enthalpy at state 2"
uB[2] = **intenergy**(F$,***v***=vB[2], ***P***=PB[2]) "internal energy at state 2"
sB[2] = **entropy**(F$, ***u***=uB[2], ***P***=PB[2]) "specific entropy at state 2"

uB[2] = uB[1]+Q*time_B12/mass_B-PB[1]*(vB[2]-vB[1]) "determine internal energy from 1st law"

"state 3B - final state of constant volume"
PB[3]=P[3] "pressure at state 3"
vB[3]=vB[2] "constant volume"
uB[3] = uB[2]+Q*time_B23/mass_B "determine internal energy from 1st law"
uB[3] = **intenergy**(F$,***v***=vB[3], ***P***=PB[3]) "internal energy at state 3"
hB[3] = **enthalpy**(F$, ***P***=PB[3], ***v***=vB[3]) "specific enthalpy at state 3"
sB[3] = **entropy**(F$, ***P***=PB[3], ***v***=vB[3]) "specific entropy at state 3"

```
TB[3] = temperature(F$, P=PB[3], v=vB[3])          "temperature at state 3"


"initial state - case C - superheated vapor"
PC[1] = 101.325[kPa]                               "pressure at state 1"
TC[1] =130[C]                                      "temperture at state 1B"
vC[1] = volume(F$, T=TC[1], P=PC[1])               "specific volume at state 1"
hC[1] = enthalpy(F$, T=TC[1],P=PC[1])              "specific enthalpy at state 1"
uC[1] = intenergy(F$, T=TC[1],P=PC[1])             "specific internal energy at state 1"
sC[1] = entropy(F$, T=TC[1], P=PC[1])              "specific entropy at state 1"
mass_C = vol[1]/vC[1]                              "mass of H2O"


"state 2C - end of constant pressure"
PC[2] = PC[1]                                      "constant pressure"
//vC[2]=vol[2]/mass_C                              "specific volume at state 2"
TC[2]=temperature(F$,u=uC[2], P=PC[2])             "temperature at state 2"
hC[2] = enthalpy(F$, u=uC[2], P=PC[2])             "specific enthalpy at state 2"
uC[2] = intenergy(F$,v=vC[2], P=PC[2])             "internal energy at state 2"
sC[2] = entropy(F$, u=uC[2], P=PC[2])              "specific entropy at state 2"

uC[2] = uC[1]+Q*time_C12/mass_C-PC[1]*(vC[2]-vC[1])                "determine
internal energy from 1st law"

 "state 3C - final state of constant volume"
PC[3]=150[kPa]                                     "pressure at state 3"
vC[3]=vC[2]                                        "constant volume"
uC[3] = uC[2]+Q*time_C23/mass_C                    "determine internal energy from 1st law"
uC[3] = intenergy(F$,v=vC[3], P=PC[3])             "internal energy at state 3"
hC[3] = enthalpy(F$, P=PC[3], v=vC[3])             "specific enthalpy at state 3"
sC[3] = entropy(F$, P=PC[3], v=vC[3])              "specific entropy at state 3"
TC[3] = temperature(F$, P=PC[3], v=vC[3])          "temperature at state 3"
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

(Case C12, Run 100)

F$ = 'steam_iapws'

$mass_A$ = 0.997 [kg]

$mass_B$ = 0.005943 [kg]

$mass_C$ = 0.0005504 [kg]

Q = 1 [kW]

time12 = 314.5 [s]

time23 = 348.5 [s]

$time_{B12}$ = 1.349 [s]

$time_{B23}$ = 13.22 [s]

$time_{C12}$ = 0.4436 [s]

$time_{C23}$ = 0.384 [s]

No unit problems were detected.

Arrays Table: Main

	uA_i [kJ/kg]	vA_i [m3/kg]	vol_i [m^3]	hA_i [kJ/kg]	sA_i [kJ/kg-K]	PA_i [kPa]	TA_i [C]	P_i [kPa]	PB_i [kPa]	TB_i [C]
1	104.8	0.001003	0.001	104.9	0.3672	101.3	25		101.3	99.97
2	420.2	0.002006	0.002	420.4	1.31	101.3	99.97		101.3	99.97
3	769.7	0.002006		771.7	2.158	1000	179.9	1000	1000	462.9

Arrays Table: Main

	hB_i [kJ/kg]	sB_i [kJ/kg-K]	uB_i [kJ/kg]	vB_i [m3/kg]	xB_i [-]	PC_i [kPa]	TC_i [C]	hC_i [kJ/kg]	sC_i [kJ/kg-K]	uC_i [kJ/kg]
1	644.7	1.912	627.7	0.1683	0.1	101.3	130	2737	7.512	2553
2	871.8	2.52	837.7	0.3366		101.3	525.1	3543	8.899	3174
3	3399	7.658	3062	0.3366		150	908	4417	9.609	3872

Arrays Table: Main

	vC_i [m3/kg]
1	1.817
2	3.634
3	3.634

Parametric Table: Case C12

	$time_{C12}$ [s]	vC_2 [m3/kg]	TC_2 [C]	PC_2 [kPa]
Run 1	0	1.817	130	101.3
Run 2	0.004481	1.836	134.1	101.3
Run 3	0.008962	1.855	138.1	101.3
Run 4	0.01344	1.875	142.2	101.3
Run 5	0.01792	1.894	146.3	101.3
Run 6	0.0224	1.913	150.4	101.3
Run 7	0.02688	1.932	154.5	101.3
Run 8	0.03137	1.951	158.6	101.3
Run 9	0.03585	1.971	162.7	101.3
Run 10	0.04033	1.99	166.9	101.3
Run 11	0.04481	2.009	171	101.3
Run 12	0.04929	2.028	175.1	101.3
Run 13	0.05377	2.047	179.2	101.3
Run 14	0.05825	2.067	183.3	101.3
Run 15	0.06273	2.086	187.5	101.3
Run 16	0.06721	2.105	191.6	101.3
Run 17	0.07169	2.124	195.7	101.3
Run 18	0.07617	2.143	199.8	101.3
Run 19	0.08065	2.162	203.9	101.3
Run 20	0.08514	2.181	208.1	101.3
Run 21	0.08962	2.2	212.2	101.3
Run 22	0.0941	2.219	216.3	101.3
Run 23	0.09858	2.238	220.4	101.3
Run 24	0.1031	2.257	224.5	101.3
Run 25	0.1075	2.276	228.6	101.3
Run 26	0.112	2.295	232.7	101.3
Run 27	0.1165	2.314	236.8	101.3
Run 28	0.121	2.333	240.9	101.3
Run 29	0.1255	2.352	245	101.3
Run 30	0.1299	2.371	249.1	101.3
Run 31	0.1344	2.389	253.2	101.3
Run 32	0.1389	2.408	257.3	101.3
Run 33	0.1434	2.427	261.4	101.3
Run 34	0.1479	2.446	265.5	101.3
Run 35	0.1523	2.464	269.5	101.3
Run 36	0.1568	2.483	273.6	101.3
Run 37	0.1613	2.502	277.7	101.3
Run 38	0.1658	2.52	281.7	101.3
Run 39	0.1703	2.539	285.8	101.3
Run 40	0.1748	2.558	289.9	101.3
Run 41	0.1792	2.576	293.9	101.3
Run 42	0.1837	2.595	298	101.3
Run 43	0.1882	2.613	302	101.3
Run 44	0.1927	2.632	306.1	101.3
Run 45	0.1972	2.651	310.1	101.3

Parametric Table: Case C12

	$time_{C12}$ [s]	vC_2 [m3/kg]	TC_2 [C]	PC_2 [kPa]
Run 46	0.2016	2.669	314.1	101.3
Run 47	0.2061	2.687	318.2	101.3
Run 48	0.2106	2.706	322.2	101.3
Run 49	0.2151	2.724	326.2	101.3
Run 50	0.2196	2.743	330.2	101.3
Run 51	0.224	2.761	334.2	101.3
Run 52	0.2285	2.779	338.2	101.3
Run 53	0.233	2.798	342.2	101.3
Run 54	0.2375	2.816	346.2	101.3
Run 55	0.242	2.834	350.2	101.3
Run 56	0.2464	2.853	354.2	101.3
Run 57	0.2509	2.871	358.2	101.3
Run 58	0.2554	2.889	362.2	101.3
Run 59	0.2599	2.907	366.1	101.3
Run 60	0.2644	2.925	370.1	101.3
Run 61	0.2688	2.944	374.1	101.3
Run 62	0.2733	2.962	378	101.3
Run 63	0.2778	2.98	382	101.3
Run 64	0.2823	2.998	386	101.3
Run 65	0.2868	3.016	389.9	101.3
Run 66	0.2913	3.034	393.8	101.3
Run 67	0.2957	3.052	397.8	101.3
Run 68	0.3002	3.07	401.7	101.3
Run 69	0.3047	3.088	405.6	101.3
Run 70	0.3092	3.106	409.6	101.3
Run 71	0.3137	3.124	413.5	101.3
Run 72	0.3181	3.142	417.4	101.3
Run 73	0.3226	3.159	421.3	101.3
Run 74	0.3271	3.177	425.2	101.3
Run 75	0.3316	3.195	429.1	101.3
Run 76	0.3361	3.213	433	101.3
Run 77	0.3405	3.231	436.9	101.3
Run 78	0.345	3.248	440.8	101.3
Run 79	0.3495	3.266	444.7	101.3
Run 80	0.354	3.284	448.6	101.3
Run 81	0.3585	3.302	452.4	101.3
Run 82	0.3629	3.319	456.3	101.3
Run 83	0.3674	3.337	460.2	101.3
Run 84	0.3719	3.355	464	101.3
Run 85	0.3764	3.372	467.9	101.3
Run 86	0.3809	3.39	471.7	101.3
Run 87	0.3853	3.407	475.6	101.3
Run 88	0.3898	3.425	479.4	101.3
Run 89	0.3943	3.442	483.2	101.3
Run 90	0.3988	3.46	487.1	101.3
Run 91	0.4033	3.477	490.9	101.3
Run 92	0.4078	3.495	494.7	101.3
Run 93	0.4122	3.512	498.5	101.3
Run 94	0.4167	3.53	502.4	101.3
Run 95	0.4212	3.547	506.2	101.3
Run 96	0.4257	3.564	510	101.3
Run 97	0.4302	3.582	513.8	101.3
Run 98	0.4346	3.599	517.6	101.3
Run 99	0.4391	3.616	521.4	101.3
Run 100	0.4436	3.634	525.1	101.3