```
"Scenario 11 - constant pressure then constant volume (fixed amount of ) 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, 1000 J heat addition"
time23=1[s]                                         "fixed amount of heat addition"
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, 1000 J heat addition"
time_B23=1[s]                                       "fixed amount of heat addition"
vB[3]=vB[2]                                         "constant volume"
uB[3] = uB[2]+Q*time_B23/mass_B                     "determine internal energy from 1st law"
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"
PB[3] = pressure(F$, u=uB[3], v=vB[3])              "pressure at state 3"
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TB[3] = temperature(F$, 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, 1000 J heat addition"
time_C23=1[s]                                                "fixed amount of heat addition"
vC[3]=vC[2]                                                  "constant volume"
uC[3] = uC[2]+Q*time_C23/mass_C                              "determine internal energy from 1st law"
hC[3] = enthalpy(F$, u=uC[3], v=vC[3])                       "specific enthalpy at state 3"
sC[3] = entropy(F$, u=uC[3], v=vC[3])                        "specific entropy at state 3"
PC[3] = pressure(F$, u=uC[3], v=vC[3])                       "pressure at state 3"
TC[3] = temperature(F$, u=uC[3], v=vC[3])                    "temperature at state 3"
```

**Parametric Table: Case C23**

| | $time_{C23}$ [s] | $vC_3$ [m3/kg] | $TC_3$ [C] | $PC_3$ [kPa] |
|---|---|---|---|---|
| Run 1 | 0 | 3.634 | 525.2 | 101.3 |
| Run 2 | 0.0101 | 3.634 | 536 | 102.7 |
| Run 3 | 0.0202 | 3.634 | 546.8 | 104.1 |
| Run 4 | 0.0303 | 3.634 | 557.6 | 105.4 |
| Run 5 | 0.0404 | 3.634 | 568.3 | 106.8 |
| Run 6 | 0.05051 | 3.634 | 578.9 | 108.2 |
| Run 7 | 0.06061 | 3.634 | 589.6 | 109.5 |
| Run 8 | 0.07071 | 3.634 | 600.1 | 110.9 |
| Run 9 | 0.08081 | 3.634 | 610.7 | 112.2 |
| Run 10 | 0.09091 | 3.634 | 621.1 | 113.5 |
| Run 11 | 0.101 | 3.634 | 631.6 | 114.9 |
| Run 12 | 0.1111 | 3.634 | 642 | 116.2 |
| Run 13 | 0.1212 | 3.634 | 652.3 | 117.5 |
| Run 14 | 0.1313 | 3.634 | 662.6 | 118.8 |
| Run 15 | 0.1414 | 3.634 | 672.9 | 120.1 |
| Run 16 | 0.1515 | 3.634 | 683.1 | 121.4 |
| Run 17 | 0.1616 | 3.634 | 693.3 | 122.7 |
| Run 18 | 0.1717 | 3.634 | 703.4 | 124 |
| Run 19 | 0.1818 | 3.634 | 713.5 | 125.3 |
| Run 20 | 0.1919 | 3.634 | 723.6 | 126.6 |
| Run 21 | 0.202 | 3.634 | 733.6 | 127.8 |
| Run 22 | 0.2121 | 3.634 | 743.6 | 129.1 |
| Run 23 | 0.2222 | 3.634 | 753.5 | 130.4 |

**Parametric Table: Case C23**

| | $time_{C23}$ [s] | $vC_3$ [m3/kg] | $TC_3$ [C] | $PC_3$ [kPa] |
|---|---|---|---|---|
| Run 24 | 0.2323 | 3.634 | 763.5 | 131.6 |
| Run 25 | 0.2424 | 3.634 | 773.3 | 132.9 |
| Run 26 | 0.2525 | 3.634 | 783.2 | 134.1 |
| Run 27 | 0.2626 | 3.634 | 793 | 135.4 |
| Run 28 | 0.2727 | 3.634 | 802.7 | 136.6 |
| Run 29 | 0.2828 | 3.634 | 812.4 | 137.8 |
| Run 30 | 0.2929 | 3.634 | 822.1 | 139.1 |
| Run 31 | 0.303 | 3.634 | 831.8 | 140.3 |
| Run 32 | 0.3131 | 3.634 | 841.4 | 141.5 |
| Run 33 | 0.3232 | 3.634 | 851 | 142.7 |
| Run 34 | 0.3333 | 3.634 | 860.6 | 144 |
| Run 35 | 0.3434 | 3.634 | 870.1 | 145.2 |
| Run 36 | 0.3535 | 3.634 | 879.6 | 146.4 |
| Run 37 | 0.3636 | 3.634 | 889.1 | 147.6 |
| Run 38 | 0.3737 | 3.634 | 898.5 | 148.8 |
| Run 39 | 0.3838 | 3.634 | 907.9 | 150 |
| Run 40 | 0.3939 | 3.634 | 917.3 | 151.2 |
| Run 41 | 0.404 | 3.634 | 926.6 | 152.4 |
| Run 42 | 0.4141 | 3.634 | 935.9 | 153.5 |
| Run 43 | 0.4242 | 3.634 | 945.2 | 154.7 |
| Run 44 | 0.4343 | 3.634 | 954.4 | 155.9 |
| Run 45 | 0.4444 | 3.634 | 963.7 | 157.1 |
| Run 46 | 0.4545 | 3.634 | 972.9 | 158.2 |
| Run 47 | 0.4646 | 3.634 | 982 | 159.4 |
| Run 48 | 0.4747 | 3.634 | 991.2 | 160.6 |
| Run 49 | 0.4848 | 3.634 | 1000 | 161.7 |
| Run 50 | 0.4949 | 3.634 | 1009 | 162.9 |
| Run 51 | 0.5051 | 3.634 | 1018 | 164 |
| Run 52 | 0.5152 | 3.634 | 1027 | 165.2 |
| Run 53 | 0.5253 | 3.634 | 1036 | 166.3 |
| Run 54 | 0.5354 | 3.634 | 1045 | 167.5 |
| Run 55 | 0.5455 | 3.634 | 1054 | 168.6 |
| Run 56 | 0.5556 | 3.634 | 1063 | 169.7 |
| Run 57 | 0.5657 | 3.634 | 1072 | 170.9 |
| Run 58 | 0.5758 | 3.634 | 1081 | 172 |
| Run 59 | 0.5859 | 3.634 | 1090 | 173.1 |
| Run 60 | 0.596 | 3.634 | 1099 | 174.2 |
| Run 61 | 0.6061 | 3.634 | 1108 | 175.4 |
| Run 62 | 0.6162 | 3.634 | 1116 | 176.5 |
| Run 63 | 0.6263 | 3.634 | 1125 | 177.6 |
| Run 64 | 0.6364 | 3.634 | 1134 | 178.7 |
| Run 65 | 0.6465 | 3.634 | 1143 | 179.8 |
| Run 66 | 0.6566 | 3.634 | 1151 | 180.9 |
| Run 67 | 0.6667 | 3.634 | 1160 | 182 |
| Run 68 | 0.6768 | 3.634 | 1169 | 183.1 |
| Run 69 | 0.6869 | 3.634 | 1177 | 184.2 |
| Run 70 | 0.697 | 3.634 | 1186 | 185.3 |
| Run 71 | 0.7071 | 3.634 | 1195 | 186.4 |
| Run 72 | 0.7172 | 3.634 | 1203 | 187.5 |
| Run 73 | 0.7273 | 3.634 | 1212 | 188.6 |
| Run 74 | 0.7374 | 3.634 | 1220 | 189.7 |
| Run 75 | 0.7475 | 3.634 | 1229 | 190.8 |
| Run 76 | 0.7576 | 3.634 | 1237 | 191.9 |
| Run 77 | 0.7677 | 3.634 | 1246 | 192.9 |
| Run 78 | 0.7778 | 3.634 | 1254 | 194 |

**Parametric Table: Case C23**

| | $time_{C23}$ [s] | $vC_3$ [m3/kg] | $TC_3$ [C] | $PC_3$ [kPa] |
|---|---|---|---|---|
| Run 79 | 0.7879 | *3.634* | *1263* | *195.1* |
| Run 80 | 0.798 | *3.634* | *1271* | *196.2* |
| Run 81 | 0.8081 | *3.634* | *1280* | *197.2* |
| Run 82 | 0.8182 | *3.634* | *1288* | *198.3* |
| Run 83 | 0.8283 | *3.634* | *1297* | *199.4* |
| Run 84 | 0.8384 | *3.634* | *1305* | *200.4* |
| Run 85 | 0.8485 | *3.634* | *1313* | *201.5* |
| Run 86 | 0.8586 | *3.634* | *1322* | *202.5* |
| Run 87 | 0.8687 | *3.634* | *1330* | *203.6* |
| Run 88 | 0.8788 | *3.634* | *1338* | *204.7* |
| Run 89 | 0.8889 | *3.634* | *1346* | *205.7* |
| Run 90 | 0.899 | *3.634* | *1355* | *206.8* |
| Run 91 | 0.9091 | *3.634* | *1363* | *207.8* |
| Run 92 | 0.9192 | *3.634* | *1371* | *208.9* |
| Run 93 | 0.9293 | *3.634* | *1380* | *209.9* |
| Run 94 | 0.9394 | *3.634* | *1388* | *210.9* |
| Run 95 | 0.9495 | *3.634* | *1396* | *212* |
| Run 96 | 0.9596 | *3.634* | *1404* | *213* |
| Run 97 | 0.9697 | *3.634* | *1412* | *214.1* |
| Run 98 | 0.9798 | *3.634* | *1420* | *215.1* |
| Run 99 | 0.9899 | *3.634* | *1429* | *216.1* |
| Run 100 | 1 | *3.634* | *1437* | *217.2* |