Cloud Physics HW1

In [ ]:
```python
#Cloud Physics Hw1
import numpy as np
from metpy.units import units
import metpy.calc as mpcalc

T, P, cp, Rd, cw, Lv = 305, 1015, 1004, 287, 4187, 2.5*10**6
P1, P2 = 910, 800

#(1),(2),(3) calculation

e = 6.11*10**(7.5*(21/(237.7+21))) #actual water vapor pressure [hPa]
es = 6.11*10**(7.5*(32/(237.7+32))) #saturated water vapor pressure [hPa]
ws = 621.97*(e/(1015-e)) #water vapor mixing ratio [g/kg]

costant = (T/(P**(Rd/(cp+ws*cw))))*np.exp((ws*Lv)/(T*(cp+ws*cw))) #not reach saturation yet, Q = ws
print("constant ≅",costant)

plevs = [1015, 910, 800] * units.hPa
Tup = mpcalc.dry_lapse(plevs, 32*units.degC).to('degC') #(1)
print("Temperature at 1015 hPa, 910 hPa, and 800 hPa:",Tup)

es1 = es*np.exp((-40700/8.3145)*((1/(22.62+273.15))-(1/T))) #not reach saturation yet, Q = ws, x = 0 #(3)
ws1 = 621.97*(e/(910-e)) #water vapor mixing ratio at 910 hPa [g/kg] #(2)
print("ws1 =", ws1)

#(4),(5),(6) calculation

es2 = es*np.exp((-40700/8.3145)*((1/(11.94+273.15))-(1/T))) #reach saturation,x = Q - ws #(6)
ws2 = 621.97*(e/(800-e)) #(5)
print("ws2 =", ws2)
print("e =",e,"es1 =",es1,"es2 =", es2)

Q = 20
for i in range (200):
    costant1 = ((11.94+273.15)/(P2**(Rd/(cp+Q*cw))))*np.exp((ws2*Lv)/((11.94+273.15)*(cp+Q*cw)))
    if abs(costant1-costant)/costant<=0.0001:
        print("Q = 20 +",0.01*i,"c =",costant1)
        break
    Q += 0.01

X2 = Q - ws2
print("χ =",X2)
```

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constant ≅ 2035.2002695554531
Temperature at 1015 hPa, 910 hPa, and 800 hPa: [32.0 22.62636978052609 11.936963647948687] degree_Celsius
ws1 = 17.44190155102202
ws2 = 19.916961059489623
e = 24.82301373016204 es1 = 28.734476895684697 es2 = 15.457513848928448
Q = 20 + 0.75 c = 2035.1107712838693
χ = 0.8330389405104945
```

$Answer: (1) = 22.6, (2) = 17.44, (3) = 0, (4) = 11.93, (5) = 19.92, (6) = 0.83$

先用地面氣溫及露點溫度計算出實際水氣壓和飽和水氣壓，以得出water vapor mixinig ratio及題目方程式的常數。此時因未飽和 $(e < e_s)$，$w_s = Q$。沿乾絕熱遞減率得出在910hPa時之氣溫約為$22.6^\circ c$，再藉由c-c equation得出此高度的飽和水氣壓。仍未達飽和，$w_{s1} = 17.44, \chi = 0$。重複步驟計算當高度為800hpa時，因已達飽和，利用題目方程式及迴圈計算接近的total water pressure數值，根據公式算出w_{s2}後，與Q相減得到χ。