Ex.1

```
ClearAll["Global`*"]

T1 := UnitConvert[ 85 °C , "K"]

T2 := UnitConvert[ 20 °C , "K"]

Cv := 4.18 kJ/(kg K) ; m := 200 g

ΔSKaffee = UnitConvert[Integrate[m * Cv / T, {T, T1, T2}], "KJ/K"]
```

Out[11]=

-0.167424 kJ/K

In[◦]:=
```
ΔSRaum = UnitConvert[Integrate[-m * Cv / T2, {T, T1, T2}], "KJ/K"]
```

Out[◦]= 0.185366 kJ/K

In[◦]:=
```
ΔSUniversum = ΔSRaum + ΔSKaffee
```

Out[◦]= 0.0179422 kJ/K

In[◦]:=
```
ClearAll["Global`*"]
ΔSUniversum =
 Integrate[-m * Cv / T2, {T, T1, T2}] + Integrate[m * Cv / T, T] - Integrate[m * Cv / t, t] ≥ 0 /.
   {T → T1, t → T2} // FullSimplify
```

Out[◦]=

$$\frac{\text{Cv}\ \text{m}\left(\text{T1} - \text{T2} + \text{T2}\ \text{Log}[\text{T1}] - \text{T2}\ \text{Log}[\text{T2}]\right)}{\text{T2}} \geq 0$$

ΔS = 0, weil es reversibel ist.

Ex.2

In[∘]:=
```
ClearAll["Global`*"]
S := kB * (3 n / 2 Log[e / n] + n Log[V / n] + n Log[c])
Eges = Solve[T == 1 / D[S, e], e][[1]][[1]]
p * V == T D[S, V] * V
μ == -T D[S, n]
```

Out[∘]= $e \to \frac{3\,kB\,n\,T}{2}$

Out[∘]= $p\,V == kB\,n\,T$

Out[∘]= $\mu == -kB\,T\left(-\frac{5}{2} + \mathrm{Log}[c] + \frac{3}{2}\,\mathrm{Log}\left[\frac{e}{n}\right] + \mathrm{Log}\left[\frac{V}{n}\right]\right)$

In[∘]:=
```
T := 300 K
p1 := 1 bar
V1 := 1 m^3
V2 := 2 m^3
kB := k
n := p1 * V1 / (T * kB) // N
p2 = UnitConvert[n * kB * T / V2, "bar"]
e1 = UnitConvert[Eges[[2]], "eV"]
e2 = UnitConvert[Eges[[2]], "eV"]
```

Out[∘]= 0.5 bar

Out[∘]= 9.36226×10^{23} eV

Out[∘]= 9.36226×10^{23} eV

In[∘]:=
$$\mu 1 = -kB\,T\left(-\frac{5}{2} + \frac{3}{2}\,\mathrm{Log}\left[\frac{e1}{n}\right] + \mathrm{Log}\left[\frac{V1}{n}\right]\right)$$
$$\mu 2 = -kB\,T\left(-\frac{5}{2} + \frac{3}{2}\,\mathrm{Log}\left[\frac{e2}{n}\right] + \mathrm{Log}\left[\frac{V2}{n}\right]\right)$$

Logs zusammenfassen

```
(*Einheiten im Log ???*)
```

Out[∘]=
$$\left(-\frac{5}{2} + \mathrm{Log}[4.14195\times 10^{-26}\ \mathrm{m}^3] + \frac{3}{2}\,\mathrm{Log}[0.038778\ \mathrm{eV}]\right)(-300\ \mathrm{K}\ k)$$

Out[∘]=
$$\left(-\frac{5}{2} + \mathrm{Log}[8.28389\times 10^{-26}\ \mathrm{m}^3] + \frac{3}{2}\,\mathrm{Log}[0.038778\ \mathrm{eV}]\right)(-300\ \mathrm{K}\ k)$$

Ex.3 Isotherme expansion

```
ClearAll["Global`*"]
kB := k ; T1 := 300 K ; V1 := 1 L ; V2 := 2 V1
p := 1 bar ; n := V1 p / (T1 R) ; Cp := 7 / 2 R
T2 := 2 T1
```

```
In[∘]:= ΔU = UnitConvert[n * Cp * (T2 - T1), "J"]
ΔS = UnitConvert[
    Integrate[n * Cp / T, {T, T1, T2}] + Integrate[n R / V, {V, V1, V2}], "J/K"] // N
ΔW = UnitConvert[+Integrate[p, {V, V1, V2}], "J"]
ΔQ = ΔU - ΔW
```

Out[∘]= 350 J

Out[∘]= 1.03972 J/K

Out[∘]= -100 J

Out[∘]= 2450 J

In[∘]:=
```
T2 := T1
ΔU = UnitConvert[n * Cp * (T2 - T1), "J"]
ΔS = UnitConvert[Integrate[n R / V, {V, V1, V2}], "J/K"] // N
```

Out[∘]= 0 J

Out[∘]= 0.231049 J/K

In[∘]:=
```
d := 1 mm; A := 0.01 m^2; F := 200 N
ΔQ := 0
```

In[∘]:=
```
ΔW = UnitConvert[F * d, "J"]
ΔU = ΔW + ΔQ
ΔT = UnitConvert[ΔU / (Cp * n)] // N
```

$c_V = \frac{5}{2} R$

Out[∘]= $\frac{1}{5}$ J

Out[∘]= $\frac{1}{5}$ J

Out[∘]= ~~0.171429~~ K 0.23 K

ΔS > 0, weil der Prozess irreversibel ist.

$\Delta S = \frac{\Delta U - p_0 \Delta V}{T_0} = -2.66 \cdot 10^{-3} \frac{J}{K}$

Ex .4

In[∘]:=
```
Na := N_A; k := k
S[options_] := UnitConvert[k * Na * Log[options], "J/K/mol"] // N
```

In[∘]:=
```
S[2]
S[6 / 4]
S[5]
```

Out[∘]= 5.76315 J/(K mol)

Out[∘]= 3.37122 J/(K mol)

Out[∘]= 13.3816 J/(K mol)

Bonus