```
ClearAll["Global`*"]
kB = 1.38064852 × 10^(-23) * m^2 * kg / s^2 / K;
Troom = 300 * K;
hbar = 6.626176 / (2 * Pi) * 10^(-34) * kg * m^2 / s
```

$$\frac{1.05459\times10^{-34}\ \mathrm{kg\ m}^2}{\mathrm{s}}$$

```
(* problem 1 *******************************************************8*)
me = 9.10938356 * 10^(-31) * kg
mcarrier = 0.04 * me
nquant = (mcarrier * kB * Troom / 2 / Pi / hbar^2)^(3 / 2)
```

$9.10938\times10^{-31}\ \mathrm{kg}$

$3.64375\times10^{-32}\ \mathrm{kg}$

$$1.00372\times10^{23}\left(\frac{1}{\mathrm{m}^2}\right)^{3/2}$$

```
(* so for original n<< nquant, as needed for ieal gas treatment,
but not true for maximally doped *)
```

```
(* problem 2 *****
 the mass times the centrifugal acceleration Omega^2*L is the force,
times l is energy
  ***********************************)
Solve[Exp[-M * Omega^2 * L * l / kB / T] == 0.01, Omega]
kB = 1.38064852 × 10^(-23) * m^2 * kg / s^2 / K;
T = 300 K;
L = 1 * m;
l = 0.05 * m;
mN = 1.67 * 10^(-27) * kg;
M = 10^6 * mN;
```

Solve: Inverse functions are being used by Solve, so some solutions may not be found; use Reduce for complete solution information.

$$\left\{\left\{\mathrm{Omega}\to-\frac{7.97378\times10^{-12}\sqrt{\mathrm{kg}}\ \mathrm{m}\sqrt{\mathrm{T}}}{\sqrt{\mathrm{K}}\sqrt{\mathrm{l}}\sqrt{\mathrm{L}}\sqrt{\mathrm{M}}\ \mathrm{s}}\right\},\left\{\mathrm{Omega}\to\frac{7.97378\times10^{-12}\sqrt{\mathrm{kg}}\ \mathrm{m}\sqrt{\mathrm{T}}}{\sqrt{\mathrm{K}}\sqrt{\mathrm{l}}\sqrt{\mathrm{L}}\sqrt{\mathrm{M}}\ \mathrm{s}}\right\}\right\}$$

$$\mathrm{Assuming}\left[m>0\ \&\&\ s>0\ \&\&\ kg>0\ \&\&\ K>0,\ \mathrm{Simplify}\left[\mathrm{Omega}=\frac{2.145966026289347`\sqrt{kB}\sqrt{T}}{\sqrt{L}\sqrt{l}\sqrt{M}}\right]\right]$$

$$\frac{15.1141}{\mathrm{s}}$$

```
(* centrifuge acceleration about 20 times g=9.8 m/s^2 *)
```

```
gcentri = (15.11408281900868`/s)^2 * L
```

$\frac{228.435\ m}{s^2}$

```
(* problem 3 *******************************************)

(* triangular cycle, (a) V0,2T0, p=R 2T0/V0
  (b) 2V0,2T0, p=R 2T0/V0  ; (c) V0,T0, p=R T0/V0 ;
the line bc is p=const isobar, so in the plot in p-V plot bc is horizontal
   S=R*log(V*T^(3/2))+const so Sa=Rlog(V0*(2T0)^(3/2)+const
        Sb=Rlog(2V0*(2T0)^(3/2)+const, Sc=Rlog(V0*(T0)^(3/2)+const

              Heat in is heat on (ab)=integral T dS=(2T0)*(Sb-Sa)=(2T_0)R*log[2]
                Work  on (ab)=integral p dV=(2T0 R) integral  dV/V=(2T0 R)log(2)
                    work on cycle is work on (ab) -(bc) since no work on (ca)

                    Work on cycle (ab-bc)=2*T0*R*log(2)-(RT0/V0)*V0
                     eta=work on cycle/heat *)

eta = 1 - (R * T0 / V0) * V0 / (2 * T0 * R * Log[2])
```

$1 - \frac{1}{2\ \mathrm{Log}[2]}$

$1 - \frac{1}{2\ \mathrm{Log}[2.]}$

0.278652

```
(* problem 4 *******************************************)

(* Maxwell relation (partial S/partial V)_T=N*KB/V
   (partial p/partial T)_V= (partial (N*kB*T/V)/partial T)=N*KB/V, the same *)

Derivatives in Jacobian
```

Derivatives in Jacobian

```
(partial T / partial p) _V = V / N / KB;
(partial T / partial V) _p = p / N / KB;
(partial S / partial p) _V = N * kB * (3 / 2) / p;
(partial S / partial V) _p = N * kB * (5 / 2) / V;
```

Set: Tag Times in (300 K p) _V is Protected.

Set: Tag Times in (300 K V) _p is Protected.

Set: Tag Times in (p S) _V is Protected.

Set: Tag Times in (S V) _p is Protected.

```
- (partial T / partial p) _V * (partial S / partial V) _p +
  (partial T / partial V) _p * (partial S / partial p) _V = -5 / 2 + 3 / 2 = -1
```

Set: Tag Plus in $-\frac{5}{2}+\frac{3}{2}$ is Protected.

Set: Tag Plus in −300 K p S V _p _V + 300 K p S V _p _V is Protected.

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