HW10

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1 Thermal Physics - Homework 10

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```
[ ]: import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from IPython.display import Math
from scipy import constants as con
from matplotlib_inline.backend_inline import set_matplotlib_formats

set_matplotlib_formats('pdf')
plt.rcParams |= {
    'text.usetex': True,
    'figure.figsize': (10, 4)
}
sns.set_theme()
set_matplotlib_formats('svg', 'pdf')
```

1.1 Question 1

The change in pressure is

$$P_2 - P_1 = \rho g \Delta h$$

And also is given by

$$P_2 - P_1 = \frac{n_B RT}{V}$$

Combine those two,

$$\rho g \Delta h = \frac{n_B RT}{V}$$

By definition number of solute moles equals the mass of the solute per molecular weight, $n_B = m/M$, so

$$\rho g \Delta h = \frac{mRT}{VM}$$

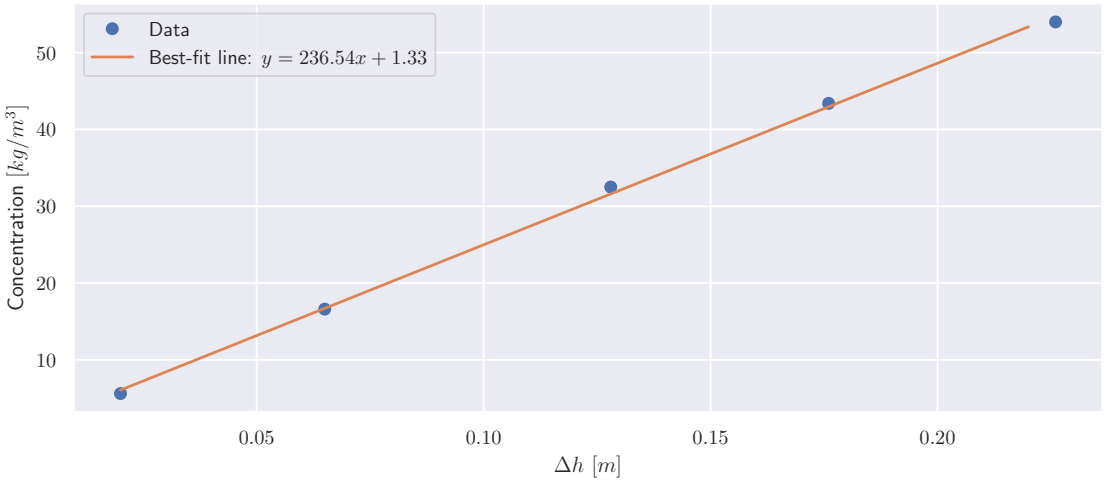
The concentration c equals the mass divided by the volume of the solution,

$$c = \frac{\rho g M}{RT} \delta h$$

Now for the given data we plot them to find the best-fit line's slop.

[ ]:
```
dh = np.array([2.0, 6.5, 12.8, 17.6, 22.6]) / 100
c = np.array([5.6, 16.6, 32.5, 43.4, 54.0]) * 1
dh_range = np.arange(dh[0], dh[-1], 0.1)
m, b = np.polyfit(dh, c, deg=1)

plt.plot(dh, c, 'o', label='Data')
plt.plot(dh_range, m * dh_range + b, label=f'Best-fit line: $y={m:.2f}x + {b:.
↪2f}$')
plt.xlabel(r'$\Delta{h}$ $[m]$')
plt.ylabel(r'Concentration $[kg/m^3]$')
plt.legend()
plt.show()
```



So we conclude that

$$\frac{\rho g M}{RT} = 236.54 \quad \Rightarrow \quad M = 236.54 \frac{RT}{\rho g} = 236.54 \frac{R \cdot 276.15}{997 * 9.8}$$

So we have

[ ]:
```
T = con.convert_temperature(3, 'c', 'k')
Math(r'\frac{\rho g M}{RT}=%.2f' % (m * con.R * T / 997 / 9.8))
```

[ ]: $$\frac{\rho g M}{RT} = 55.59$$