HW2

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1 Homework 2

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[14]:
```
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import constants as con
from matplotlib_inline.backend_inline import set_matplotlib_formats

set_matplotlib_formats('svg', 'pdf')
plt.rcParams['figure.figsize'] = [4, 3]
sns.set_theme()
```

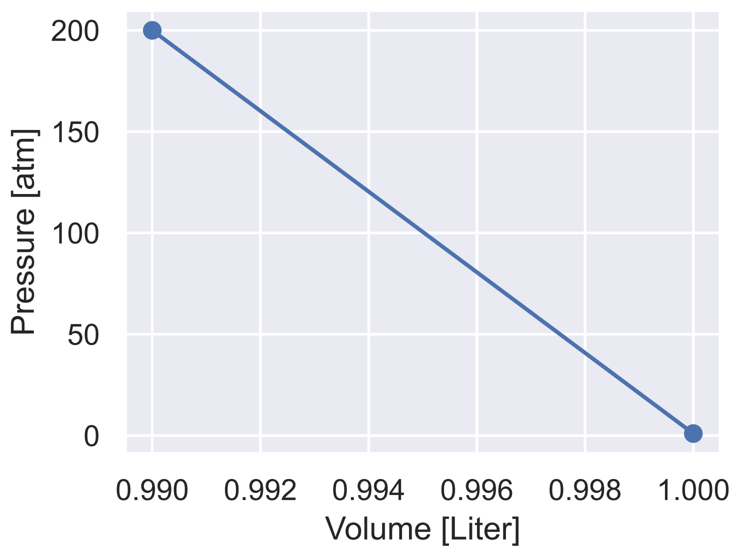
1.1 Problem 1.32

To approximate the the work needed, we take the average pressure as 100 atm.

$$W \approx -\bar{P}\Delta V = -(100 \text{ atm})(-0.001 \text{ L}) = 100 \text{ J}$$

[13]:
```
plt.plot([0.99, 1.00], [200, 1.00], '-o')

plt.xlabel('Volume [Liter]')
plt.ylabel('Pressure [atm]')
plt.show()
```



1.2 Problem 1.33

1.2.1 Step A

$W < 0$, $\Delta U > 0$, and $Q > 0$

1.2.2 Step B

$W = 0$, $\Delta U > 0$, and $Q > 0$

1.2.3 Step C

$W > 0$, $\Delta U < 0$, and $Q < 0$

1.2.4 Whole cycle

$W > 0$, $\Delta U = 0$, and $Q < 0$

This cycle process can move heat, so it's similar to the concept of refrigerator.

1.3 Problem 1.37

Compression of air to 1/20 of its original heat means $V_f = V_i/20$, for air we have $f = 5$ and $T_i = 300$ K. So from equation

$$V_f T_f^{f/2} = V_i T_i^{f/2}$$

Then final temperature will be

$$T_f = T_i \left(\frac{V_i}{V_f}\right)^{2/f} = (300 \text{ K})(20)^{2/5} = 993K$$

this high temperature can ignite fuel without having a spark.

1.4 Probolem 1.43

Take one mole of water H_2O, which is 18 g, we know the specific heat of water is 4.186 J/K, the heat hapacity is

$$C = 18(4.186) = 75.348 \text{ kg J/k}$$

And heat capacity per molecule is

$$\frac{C}{N} = \frac{75.348 \text{ kg J/k}}{N_A \cdot 1mol}$$

[3]:
```
print(f'{75.348 / con.N_A} J/K = {75.348 / con.N_A / con.k:.2f}k')
```

```
1.25118297633415e-22 J/K = 9.06k
```

If the thermal energy is all stored in terms of quadratic degree of freedom, each one will get a heat capacity of k/2, then there sould be $9.06k \cdot 2 =$

[4]:
```
print(f'{75.348 / con.N_A / con.k * 2} ~ 18 degrees of freedom')
```

```
18.124562815518644 ~ 18 degrees of freedom
```

Since we know the exact structure of the water molecule, this is to large number of degree of fredom, there should be other non-quadratic degree of freedom wehre the excess of energy stored.

1.5 Probolem 1.51

The change in enthalpy of glucose deformation into $\mathrm{H_2}$ and $\mathrm{O_2}$ is negative of its formation, from page 404

$$\Delta_1 H = +1273 \text{ kJ}$$

But to form $6\mathrm{CO_2}$ and $6\mathrm{H_2O}$, we have also

$$\Delta_2 H = 6(-393.5 \text{ kJ}) + 6(-285.8 \text{ kJ}) = -4076 \text{ kJ}$$

Then the total change in enthalpy is $\Delta_1 H + \Delta_2 H =$

[5]:
```
print(f'{1273-4076} kJ')
```

```
-2803 kJ
```