van der Waals pt. 2

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In [ ]:
```
import numpy as np
import scipy.optimize as opt
import matplotlib.pyplot as plt

a = 0.3634
b = 4.236e-5
R = 8.314
P = 5e5

def vdWT(V, T):
    return (R * T) - ((P + (a / V**2)) * (V - b))
```

question 2 c. i.

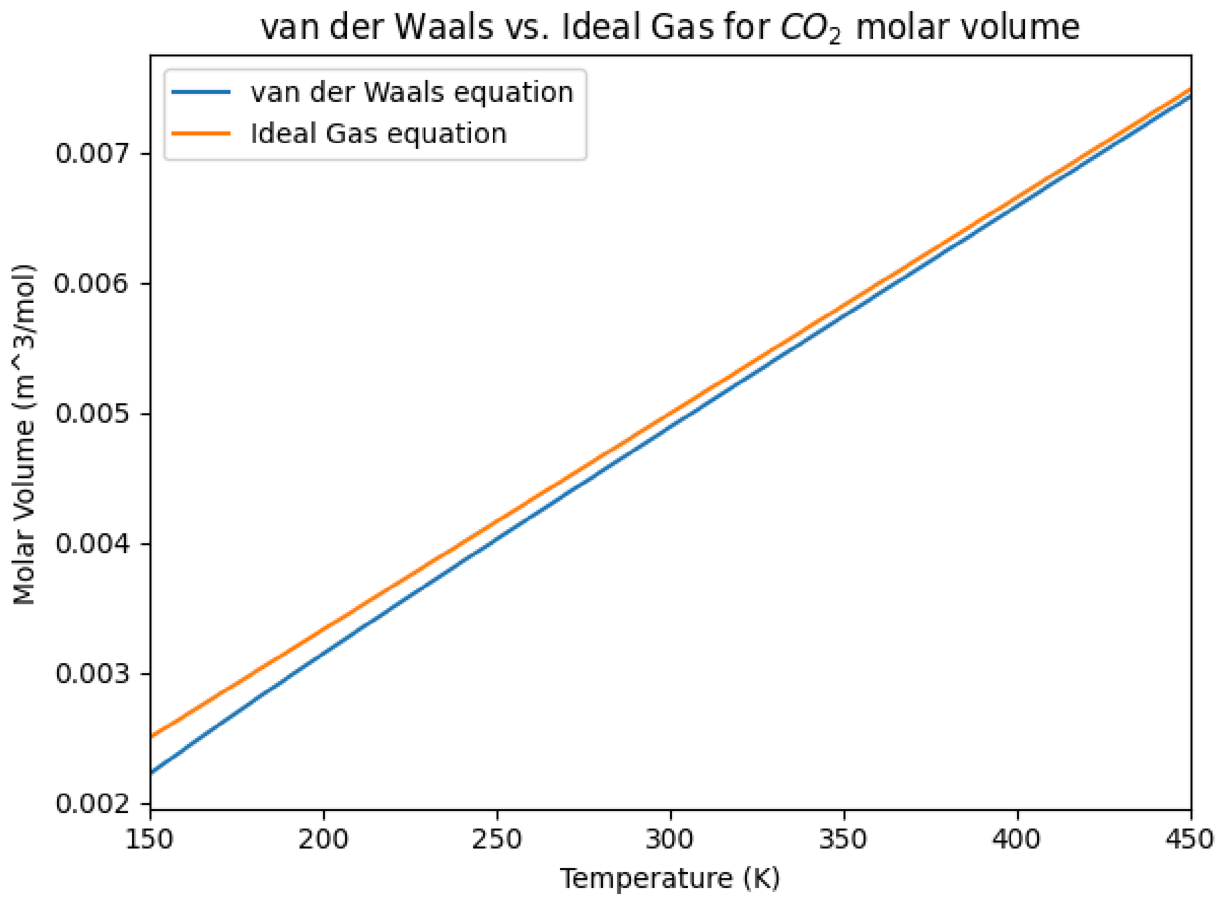
In [ ]:
```
temperatures = np.linspace(150,450,100)

vdw_volumes = np.array([opt.fsolve(vdWT, R*T/P, args=(T))[0] for T in temperatu

ideals = R * temperatures / P

plt.plot(temperatures, vdw_volumes, label='van der Waals equation')
plt.plot(temperatures, ideals, label='Ideal Gas equation')
plt.xlim(150,450)
plt.xlabel('Temperature (K)')
plt.ylabel('Molar Volume (m^3/mol)')
plt.title('van der Waals vs. Ideal Gas for $CO_2$ molar volume')
plt.tight_layout()
plt.legend()
```

Out[ ]:
```
<matplotlib.legend.Legend at 0x15a623350>
```



the trend is that as temperature increases so does molar volume for both ideal and van der Waals. the values are overall quite similar, especially in the second half of the temperature range.

2 c. ii. plotting normalized difference

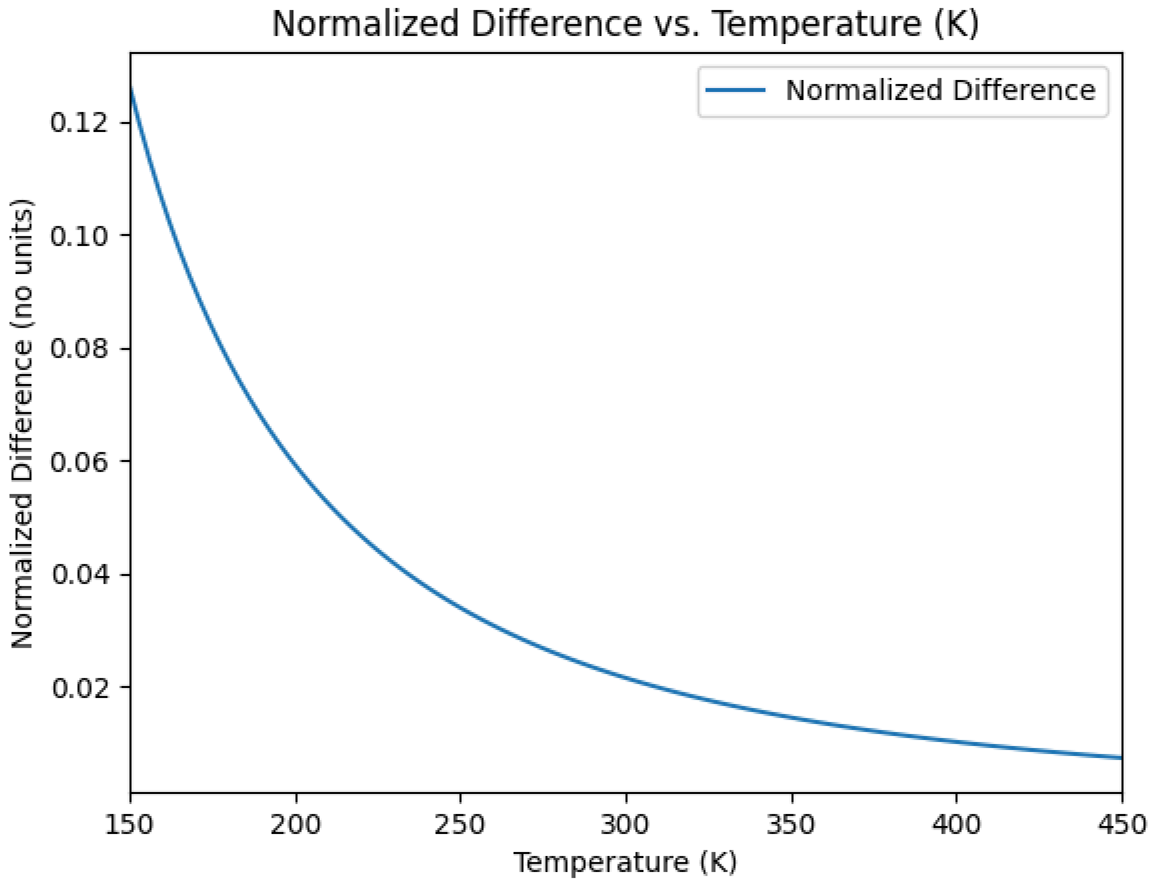
In [ ]:

```
normalized_difference = abs(ideals - vdw_volumes) / vdw_volumes

plt.plot(temperatures, normalized_difference, label='Normalized Difference')
plt.xlim(150,450)
plt.xlabel('Temperature (K)')
plt.ylabel('Normalized Difference (no units)')
plt.title('Normalized Difference vs. Temperature (K)')
plt.legend()
```

Out[ ]:

```
<matplotlib.legend.Legend at 0x15a78ab10>
```



the trend is that as temperature increases the normalized difference decreases. this might be exponential or could also be proportional to reciprocal temperature.