Quiz 2.1 – Internal energy

Name: Key

Ideal Gas Heat Capacities

○ Give the constant volume heat capacities (in the low temperature limit) for perfect gases with the following geometries:

1. Monoatomic ~~$\frac{3}{2}R$~~ $\frac{3}{2}R$
2. Linear Diatomic $\frac{5}{2}R$
3. Non-linear Polyatomic $3R$

○ Describe qualitatively what would happen to these heat capacities in the high temperature limit and why

They would increase as vibrations become thermally activated.

○ Explain why we must designate constant pressure or constant volume for heat capacities

Some heat is converted to work as a gas expands at constant pressure. This energy will not contribute to ΔT.

○ Predict qualitatively how C_V might compare to C_p for a gas at a given temperature

Because some heat is spent on work at constant pressure, more heat is required to change the temperature

$C_p > C_v$

Work

$\rightarrow 307.15\,K$

One mole of gas at $34°C$ undergoes an isothermal expansion in two stages:

1. From $5.0\ L$ to $7.5\ L$
2. From $7.5\ L$ to $10.0\ L$

$W = -nRT\ln\left(\frac{V_f}{V_i}\right)$

o Find the work (w_{sys}) at each stage

1) $W = -1\,mol \cdot 8.314\ J/mol{\cdot}K \cdot 307.15\,K \cdot \ln\left(\frac{7.5\,L}{5.0\,L}\right) = -1040\,J$ 2) $W = -1\,mol \cdot 8.314\ J/mol{\cdot}K \cdot 307.15\,K \cdot \ln\left(\frac{10.0\,L}{7.5\,L}\right) = -735\,J$

o Explain why the work done is not equal, even though the volume changes are the same

The pressure is lower throughout stage 2

o The gas then undergoes an isothermal compression where $w_{sys} = 5500\ J$. What is the final volume?

$5500\,J = -1\,mol \cdot 8.314\,\frac{J}{mol{\cdot}K} \cdot 307.15\,K \cdot \ln\left(\frac{V_f}{10.0\,L}\right) \rightarrow \ln\left(\frac{V_f}{10.0\,L}\right) = -2.154$

$e^{\wedge}$ $e^{\wedge}$

$V_f = 0.116 \cdot 10.0\,L = 1.16\,L$

Heat

o $10.0\ g$ of He gas at $20.0°C$ are heated by $315\ J$ at constant volume. What is the final temperature of the gas? $\rightarrow$ 2.498 moles $C_v = \frac{3}{2}R$

$q = nC_v\Delta T$ $315\,J = 2.498\,moles \cdot \frac{3}{2}\,8.314\,J/mol{\cdot}K \cdot \Delta T \rightarrow 10.1°C$ $T_f = 30.1°C$

o $10.0\ g$ of N_2 gas at $20.0°C$ are heated by $315\ J$ at constant volume. What is the final temperature of the gas? $\rightarrow$ 0.3570 moles $C_v = \frac{5}{2}R$

six !!

$q = nC_v\Delta T$ $315\,J = 0.3570\,moles \cdot \frac{5}{2}\,8.314\,J/mol{\cdot}K \cdot \Delta T \rightarrow \Delta T = 42.5\,K$ $T_f = 62.5°C$

o Find the heat (q_{sys}) required to cool $10.0\ g$ of methane gas by $5°C$ at constant volume

$\rightarrow$ 0.6234 moles $C_v = 3R$

$q = nC_v\Delta T = 0.6234\,moles \cdot 3 \cdot 8.314\,J/mol\,K \cdot -5\,K = -77.7\,J$