Answer on #70208, Physics / Molecular Physics | Thermodynamics

Question. When a monoatomic ideal gas expands at a constant pressure of $5.4 \cdot 10^5\ Pa$, the volume of the gas increases by $4.6 \cdot 10^{-3}\ m^3$. Determine the heat that flows. If heat flows into the gas, then the heat flow is positive. If the heat flows out of the gas, then the heat flow is negative.

Given: $p = 5.4 \cdot 10^5\ Pa; p = const$, the process is isobaric.

$\Delta V = 4.6 \cdot 10^{-3}\ m^3.$

Find: $Q - ?.$

Solution. In accordance with the first law of thermodynamics

$$\boldsymbol{Q = \Delta U + A},$$

where Q – the amount of heat supplied to the system; ΔU – the change in the internal energy; A – the amount of work done by the system.

For the isobaric process

$$A = p \cdot \Delta V,$$

The change in the internal energy

$$\Delta U = \frac{m}{M}\frac{i}{2} R\Delta T,$$

where i – degrees of freedom of gas molecules. For a monoatomic ideal gas $i = 3$.

For the ideal gas

$$p \cdot \Delta V = \frac{m}{m} R\Delta T.$$

Finally, we have

$$Q = \Delta U + A = \frac{m}{M}\frac{i}{2} R\Delta T + p \cdot \Delta V = \frac{m}{M} R\Delta T \frac{i}{2} + p \cdot \Delta V = p \cdot \Delta V \cdot \frac{i}{2} + p \cdot \Delta V = p \cdot \Delta V \cdot \left(1 + \frac{i}{2}\right) =$$

$$= p \cdot \Delta V \frac{i+2}{2}.$$

$$Q = p \cdot \Delta V \cdot \frac{i+2}{2} = 5.4 \cdot 10^5 \cdot 4.6 \cdot 10^{-3} \cdot \frac{3+2}{2} = +62.1 \cdot 10^2\ J.$$

Answer: $Q = p \cdot \Delta V \cdot \frac{i+2}{2} = +62.1 \cdot 10^2\ J.$