Calculate the work done by one mole of a Van der Waals' gas if during its isothermal expansion its volume increases from 1 m^3 to 2 m^3 at a temperature 300 K. Take a=1.39·10^{-6} atm·m^6·mol^{-2} and b = 39.1·10^{-6} m^3·mol^{-1}.

Solution: As you know, work of 1 mol of gas can be calculated as: $W = \int_{\upsilon_1}^{\upsilon_2} p d\upsilon$; where υ is the molar volume, m^3/mol. The Van der Waals equation of state for 1 mole of gas is: $\left(p + \frac{a}{\upsilon^2}\right) \cdot (\upsilon - b) = R_0 T;$

From this equation we obtain that $p = \frac{R_0 T}{\upsilon - b} - \frac{a}{\upsilon^2};$

Then, $W = \int_{\upsilon_1}^{\upsilon_2} \left(\frac{R_0 T}{\upsilon - b} - \frac{a}{\upsilon^2}\right) d\upsilon = \int_{\upsilon_1}^{\upsilon_2} \frac{R_0 T}{\upsilon - b} d\upsilon - \int_{\upsilon_1}^{\upsilon_2} \frac{a}{\upsilon^2} d\upsilon = R_0 T \cdot \ln\frac{\upsilon_2 - b}{\upsilon_1 - b} + a \cdot \left(\frac{1}{\upsilon_2} - \frac{1}{\upsilon_1}\right);$

Where $\upsilon = \frac{V}{n}; \upsilon_1 = \frac{1}{1} = 1 \frac{m^3}{mol}; \upsilon_2 = \frac{2}{1} = 2 \frac{m^3}{mol};$ also, we must convert the value of coefficient *a* into the SI units: *a* = 1.39·10^{-6}·101,325 N·m^{-2}·m^6·mol^{-2} = 0.141 N·m^4·mol^{-2}.

$$W = 8.314 \cdot 300 \cdot \ln\frac{2 - 39.1 \cdot 10^{-6}}{1 - 39.1 \cdot 10^{-6}} + 0.141 \cdot \left(\frac{1}{2} - \frac{1}{1}\right) = 1728.8 \text{ J};$$

Answer: 1728.8 J.