Important Basic Relationship of Thermodynamics Formulas PDF

Formulas
Examples
with Units

List of 22
Important Basic Relationship of Thermodynamics Formulas

1) Absolute Pressure given Absolute Temperature Formula

Evaluate Formula

Formula

$$P_{abs} = \rho_{gas} \cdot R_{specific} \cdot T_{Abs}$$

Example with Units

$$53688.516\,\text{Pa} = 1.02\,\text{kg/m}^3 \cdot 287\,\text{J/kg*K} \cdot 183.4\,\text{K}$$

2) Absolute Temperature given Absolute Pressure Formula

Evaluate Formula

Formula

$$T_{Abs} = \frac{P_{abs}}{\rho_{gas} \cdot R_{specific}}$$

Example with Units

$$183.3999\,\text{K} = \frac{53688.5\,\text{Pa}}{1.02\,\text{kg/m}^3 \cdot 287\,\text{J/kg*K}}$$

3) Change in Internal Energy given Total Heat Supplied to Gas Formula

Evaluate Formula

Formula

$$\Delta U = H - w$$

Example with Units

$$9400\,\text{J} = 39.4\,\text{KJ} - 30\,\text{KJ}$$

4) Constant for External Work Done in Adiabatic process Introducing Pressure Formula

Evaluate Formula

Formula

$$C = \left(\left(\frac{1}{w}\right) \cdot \left(P_1 \cdot v_1 - P_2 \cdot v_2\right)\right) + 1$$

Example with Units

$$0.5227 = \left(\left(\frac{1}{30\,\text{KJ}}\right) \cdot \left(2.5\,\text{Bar} \cdot 1.64\,\text{m}^3\text{/kg} - 5.2\,\text{Bar} \cdot 0.816\,\text{m}^3\text{/kg}\right)\right) + 1$$

5) Continuity Equation for Compressible Fluids Formula

Evaluate Formula

Formula

$$A = \rho_f \cdot A_{cs} \cdot V_{Avg}$$

Example with Units

$$991516.5 = 997\,\text{kg/m}^3 \cdot 13\,\text{m}^2 \cdot 76.5\,\text{m/s}$$

6) External Work Done by Gas given Total Heat Supplied Formula

Evaluate Formula

Formula

$$w = H - \Delta U$$

Example with Units

$$30\,\text{KJ} = 39.4\,\text{KJ} - 9400\,\text{J}$$

7) External Work Done by Gas in Adiabatic Process Introducing Pressure Formula

Evaluate Formula

Formula

$$w = \left(\frac{1}{C - 1}\right) \cdot \left(P_1 \cdot v_1 - P_2 \cdot v_2\right)$$

Example with Units

$$28.64\,\text{KJ} = \left(\frac{1}{0.5 - 1}\right) \cdot \left(2.5\,\text{Bar} \cdot 1.64\,\text{m}^3/\text{kg} - 5.2\,\text{Bar} \cdot 0.816\,\text{m}^3/\text{kg}\right)$$

8) Gas Constant given Absolute Pressure Formula

Evaluate Formula

Formula

$$R_{specific} = \frac{P_{abs}}{\rho_{gas} \cdot T_{Abs}}$$

Example with Units

$$286.9999\,\text{J/kg*K} = \frac{53688.5\,\text{Pa}}{1.02\,\text{kg/m}^3 \cdot 183.4\,\text{K}}$$

9) Kinetic Energy given Total Energy in Compressible Fluids Formula

Evaluate Formula

Formula

$$KE = E_{(Total)} - \left(PE + E_p + E_m\right)$$

Example with Units

$$75\,\text{J} = 279\,\text{J} - \left(4\,\text{J} + 50\,\text{J} + 150\,\text{J}\right)$$

10) Mass Density given Absolute Pressure Formula

Evaluate Formula

Formula

$$\rho_{gas} = \frac{P_{abs}}{R_{specific} \cdot T_{Abs}}$$

Example with Units

$$1.02\,\text{kg/m}^3 = \frac{53688.5\,\text{Pa}}{287\,\text{J/kg*K} \cdot 183.4\,\text{K}}$$

11) Molecular Energy given Total Energy in Compressible Fluids Formula

Evaluate Formula

Formula

$$E_m = E_{(Total)} - \left(KE + PE + E_p\right)$$

Example with Units

$$150\,\text{J} = 279\,\text{J} - \left(75\,\text{J} + 4\,\text{J} + 50\,\text{J}\right)$$

12) Potential Energy given Total Energy in Compressible Fluids Formula

Evaluate Formula

Formula

$$PE = E_{(Total)} - \left(KE + E_p + E_m\right)$$

Example with Units

$$4\,\text{J} = 279\,\text{J} - \left(75\,\text{J} + 50\,\text{J} + 150\,\text{J}\right)$$

13) Pressure Energy given Total Energy in Compressible Fluids Formula

Evaluate Formula

Formula

$$E_p = E_{(Total)} - \left(KE + PE + E_m\right)$$

Example with Units

$$50\,\text{J} = 279\,\text{J} - \left(75\,\text{J} + 4\,\text{J} + 150\,\text{J}\right)$$

14) Pressure for External Work Done by Gas in Adiabatic Process Introducing Pressure Formula

Evaluate Formula

Formula

$$P_2 = -\frac{(w \cdot (C - 1)) - (P_1 \cdot v_1)}{v_2}$$

Example with Units

$$5.2083\,\text{Bar} = -\frac{(30\,\text{KJ} \cdot (0.5 - 1)) - (2.5\,\text{Bar} \cdot 1.64\,\text{m}^3/\text{kg})}{0.816\,\text{m}^3/\text{kg}}$$

15) Pressure given Constant Formula

Evaluate Formula

Formula

$$p_c = \frac{R_a}{v}$$

Example with Units

$$0.0497\,\text{Pa} = \frac{5.47\text{e-}1\,\text{J/kg*K}}{11\,\text{m}^3/\text{kg}}$$

16) Specific Volume for External Work Done in Adiabatic Process Introducing Pressure Formula

Evaluate Formula

Formula

$$v_1 = \frac{(w \cdot (C - 1)) + (P_2 \cdot v_2)}{P_1}$$

Example with Units

$$1.6373\,\text{m}^3/\text{kg} = \frac{(30\,\text{KJ} \cdot (0.5 - 1)) + (5.2\,\text{Bar} \cdot 0.816\,\text{m}^3/\text{kg})}{2.5\,\text{Bar}}$$

17) Total Energy in Compressible Fluids Formula

Evaluate Formula

Formula

$$E_{(Total)} = KE + PE + E_p + E_m$$

Example with Units

$$279\,\text{J} = 75\,\text{J} + 4\,\text{J} + 50\,\text{J} + 150\,\text{J}$$

18) Total Heat Supplied to Gas Formula

Evaluate Formula

Formula

$$H = \Delta U + w$$

Example with Units

$$39.4\,\text{KJ} = 9400\,\text{J} + 30\,\text{KJ}$$

19) Boyle's law Formulas

19.1) Boyle's Law According to Adiabatic Process Formula

Evaluate Formula

Formula

$$R_a = p_c \cdot \left(v^{C}\right)$$

Example with Units

$$198.9975\,\text{J/kg*K} = 60\,\text{Pa} \cdot \left(11\,\text{m}^3/\text{kg}^{0.5}\right)$$

19.2) Boyle's Law According to Isothermal Process Formula

Evaluate Formula

Formula

$$R_a = p_c \cdot v$$

Example with Units

$$660\,\text{J/kg*K} = 60\,\text{Pa} \cdot 11\,\text{m}^3\text{/kg}$$

19.3) Boyle's Law given Mass Density Formula

Evaluate Formula

Formula

$$R_a = \frac{p_c}{\rho_f^{C}}$$

Example with Units

$$1.9002\,\text{J/kg*K} = \frac{60\,\text{Pa}}{997\,\text{kg/m}^3{}^{0.5}}$$

19.4) Boyle's Law given Weight Density in Adiabatic Process Formula

Evaluate Formula

Formula

$$R_a = \frac{p_c}{\omega^{C}}$$

Example with Units

$$0.2683\,\text{J/kg*K} = \frac{60\,\text{Pa}}{0.05\,\text{g/mm}^3{}^{0.5}}$$

Variables used in list of Basic Relationship of Thermodynamics Formulas above

- **A** Constant A1
- **A_{cs}** Cross-Sectional Area of Flow Channel *(Square Meter)*
- **C** Heat Capacity Ratio
- **$E_{(Total)}$** Total Energy in Compressible Fluids *(Joule)*
- **E_m** Molecular Energy *(Joule)*
- **E_p** Pressure Energy *(Joule)*
- **H** Total Heat *(Kilojoule)*
- **KE** Kinetic Energy *(Joule)*
- **P_1** Pressure 1 *(Bar)*
- **P_2** Pressure 2 *(Bar)*
- **P_{abs}** Absolute Pressure by Fluid Density *(Pascal)*
- **p_c** Pressure of Compressible Flow *(Pascal)*
- **PE** Potential Energy *(Joule)*
- **R_a** Gas Constant a *(Joule per Kilogram K)*
- **$R_{specific}$** Ideal Gas Constant *(Joule per Kilogram K)*
- **T_{Abs}** Absolute Temperature of Compressible Fluid *(Kelvin)*
- **v** Specific Volume *(Cubic Meter per Kilogram)*
- **v_1** Specific Volume for Point 1 *(Cubic Meter per Kilogram)*
- **v_2** Specific Volume for Point 2 *(Cubic Meter per Kilogram)*
- **V_{Avg}** Average Velocity *(Meter per Second)*
- **w** Work Done *(Kilojoule)*
- **ΔU** Change in Internal Energy *(Joule)*
- **ρ_f** Mass Density of Fluid *(Kilogram per Cubic Meter)*
- **ρ_{gas}** Mass Density of Gas *(Kilogram per Cubic Meter)*
- **ω** Weight Density *(Gram per Cubic Millimeter)*

Constants, Functions, Measurements used in list of Basic Relationship of Thermodynamics Formulas above

- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Pressure** in Pascal (Pa), Bar (Bar)
  Pressure Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Energy** in Joule (J), Kilojoule (KJ)
  Energy Unit Conversion
- Measurement: **Mass Concentration** in Kilogram per Cubic Meter (kg/m³)
  Mass Concentration Unit Conversion
- Measurement: **Density** in Gram per Cubic Millimeter (g/mm³)
  Density Unit Conversion
- Measurement: **Specific Volume** in Cubic Meter per Kilogram (m³/kg)
  Specific Volume Unit Conversion
- Measurement: **Specific Entropy** in Joule per Kilogram K (J/kg*K)
  Specific Entropy Unit Conversion

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