

Instructions: You have a total of 55 minutes to complete this test. Answer each of the following questions completely providing details and correct SI units.

Time Start _____ Time finish _____ pledged _____

[1] An ideal **3 dimensional diatomic gas with vibrational and rotational modes realized** has the equation of state $PV=nRT$ where n is the number of moles and $R=8.314 \text{ J/(K mol)}$. **You may assume $n=1$ mole for this entire problem.**

(a) Calculate c_p and the adiabatic coefficient γ for this gas, providing numerical answers with correct SI units.

$C_p =$ _____

$\gamma =$ _____

(b) Suppose that the ideal gas in (a) had an initial volume of $V_i=1 \text{ m}^3$ and went through an **isothermal process ($T=T_i=300 \text{ K}$)** which resulted in $V_f=2 \text{ m}^3$. **Providing correct SI units, calculate the following:**

$P_i =$ _____

$Q =$ _____

$W =$ _____

$\Delta U =$ _____

(c) Suppose that the same gas went through an **isovolumeric ($V=V_i$)** process which resulted in $T_f=600 \text{ K}$ where $T_i=300 \text{ K}$ with P changing from P_i to P_f . **Providing correct SI units, calculate the following:**

$\Delta U =$ _____

$W =$ _____

$Q =$ _____

[2] An unknown solid material is observed to have a length of $L_0=1$ m at 0°C and a length of $L=1.5$ m at 200°C . **In your answers, be sure to use correct SI units.**

(a) Calculate the coefficient of linear expansion for this material.

$\alpha =$ _____

(b) A different material (**not the same material as in part a**) has a coefficient of volume expansion given by $\gamma = 3.0 \times 10^{-1} / ^\circ\text{C}$. Suppose a cube of this material with a volume $V_0 = 1$ m³ is heated from 0°C to 200°C , calculate the work done when it expands against a constant pressure of $P = 1 \times 10^5$ Pa.

$W =$ _____

(c) Suppose the material in (b) above has a density of $\rho = 400$ kg/m³ and a specific heat at a constant pressure of $c_p = 200$ J/(kg $^\circ\text{C}$). Calculate the heat supplied to the system.

$Q =$ _____

(d) Calculate ΔU when the material in (b) above is expanded (as in b) and simultaneously heated (as in c).

$\Delta U =$ _____

[3] A heat engine is reported to operate with 65% efficiency ($\epsilon=0.65$) when the cold reservoir is at 27°C .

(a) Suppose 100 Joules of work was done by this engine. What was the heat input to the engine?

$Q_H =$ _____

(b) If this engine follows the Carnot cycle, what is the temperature of the hot reservoir (in K)?

$T_H =$ _____

(c) Suppose the heat input to this engine had been $Q_H=500\text{ J}$. Calculate the work done by this engine.

$W =$ _____

(d) Suppose the heat input to this engine was $Q_H=500\text{ J}$. Calculate the heat rejected by this engine.

$Q_c =$ _____

[4] For water, $L_f = 3.33 \times 10^5 \text{ J/kg}$ and $c = 4186 \text{ J/Kg } ^\circ\text{C}$. **In your answers, be sure to use correct SI units.**

(a) If 2 kg of water at 0°C is mixed with 1 kg of water at 75°C , calculate the final equilibrium temperature of the mixture.

$T_f =$ _____

(b) Calculate the change in entropy of the water as a result of the mixing described in part a, be sure to provide correct SI units.

$\Delta S =$ _____

(c) If a 2 kg mass of water at 0°C freezes to become ice at 0°C , calculate the change in entropy of the ice.

$\Delta S =$ _____