

Instructions: You have a total of 50 minutes to complete this test. Answer each of the following questions completely providing details and correct SI units.

Time Start _____ Time finish _____ pledged _____

Constants: $R=8.314 \text{ J/(K mol)}$; water: $c=4186 \text{ J/(}^\circ\text{C kg)}$, $L_f=3.33 \times 10^5 \text{ J/kg}$

[1] An ideal 3 dimensional diatomic gas with rotational modes realized but not vibrational modes has the equation of state $PV=nRT$ where n is the number of moles. **You may assume $n=2$ moles for this entire problem.**

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

$c_v =$ _____

$c_p =$ _____

$\gamma =$ _____

For the rest of this problem, use $c_v=(3/2) R$ and $c_p=(5/2)R$

(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 $T_i=200 \text{ K}$ 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 $L=1.4$ m at 100°C . **In your answers, be sure to use correct SI units.**

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

$$\alpha = \underline{\hspace{2cm}}$$

(b) A different material (**not the same material as in part a**) has a coefficient of volume expansion given by $\gamma=2.0 \times 10^{-2}/\text{C}$. Suppose a cube of this material with a volume $V_0=1$ m³ is heated from 0°C to 100°C , calculate the work done when it expands against a constant pressure of $P=1 \times 10^5$ Pa.

$$W = \underline{\hspace{2cm}}$$

(c) Suppose the material in (b) above has a mass of 300 kg and a specific heat at a constant pressure of $c_p=10$ J/(kg $^\circ\text{C}$). Calculate the heat supplied to the system.

$$Q = \underline{\hspace{2cm}}$$

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

$$\Delta U = \underline{\hspace{2cm}}$$

[3] A heat engine produces 50 Joules of work for a heat input of 200 J.

(a) Calculate the efficiency of this engine.

$$\varepsilon = \underline{\hspace{2cm}}$$

(b) How much heat does this engine reject?

$$Q_c = \underline{\hspace{2cm}}$$

(c) Suppose this engine operates with a lower temperature of $T_c = 100^\circ\text{C}$. If the engine has an efficiency equal to the Carnot efficiency, what is the temperature of the hotter reservoir?

$$T_H = \underline{\hspace{2cm}}$$

[4](a) If 1 kg of water at 0°C is mixed with 1 kg of water at 100°C , calculate the final equilibrium temperature of the mixture.

$T_f =$ _____

[4](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.

$\Delta S =$ _____

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

$\Delta S =$ _____