

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 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 here.

(a) Calculate c_p for this ideal gas when all 7 degrees of freedom are realized.

For the rest of this problem, assume $c_v=3/2 R$ and $c_p=5/2 R$.

(b) Suppose $n=1$ moles of this gas went through an isothermal process at $T=300\text{K}$ which resulted in $V_f=3V_i$ with V_i being the initial volume of the gas. Calculate the following quantities:

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

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

(c) Suppose $n=1$ moles of this gas went through an isobaric process at $P=1.0 \times 10^2 \text{ Pa}$ and the volume changed from 1 m^3 to 3 m^3 . Calculate the following quantities:

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

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

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

[2] An unknown solid material is observed to have a length of 1 m at 0 °C and a length of 1.10 m at 100 °C.

(a) What is the coefficient of linear expansion for this material?

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

(b) Another material (not the same material as in part a) has a coefficient of linear expansion given by $\alpha = 2 \times 10^{-3} / \text{C}$. Calculate the coefficient of volume expansion for this material assuming the material is isotropic.

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

For the rest of this problem, assume $\gamma = 4 \times 10^{-3} / \text{C}$.

(c) If a cube of the material in (b) above with a volume $V_0 = 1 \text{ m}^3$ is heated from 0 °C to 100 °C, calculate the work done when it expands against a constant pressure of $P = 1 \times 10^5 \text{ Pa}$.

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

(d) Suppose the material in (b) above has a mass of 800 kg and a specific heat of $c_p = 2 \text{ J} / (\text{kg } ^\circ\text{C})$. Calculate the heat supplied to the system.

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

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

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

[3] A heat engine is reported to operate with 25 % efficiency when the cold reservoir is at 0°C .

(a) Assuming this engine follows the Carnot cycle, what is the temperature of the hot reservoir?

$T_H =$ _____

(b) Suppose the heat input to this engine was 10 J. Calculate the work done by this engine.

$W =$ _____

(c) Suppose the heat input to this engine was 10J. Calculate the heat rejected by this engine.

$Q_C =$ _____

[4] For water, $L_f = 3.33 \times 10^5$ J/kg and $c = 4186$ J/Kg $^{\circ}\text{C}$.

(a) If 4 kg of water at 0°C is mixed with 1 kg of water at 80°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. Hint: make sure your result is positive.

$\Delta S =$ _____

(c) If a 5 kg mass of ice at 0°C melts to become water at 0°C , calculate the change in entropy of the system.

$\Delta S =$ _____