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 _________________

[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 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.

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

$\Delta U =$ ___________________

$Q =$ ____________________

(c) Suppose n=1 moles of this gas went through an isobaric process at P=1.0x10^2 Pa and the volume changed from 1 m^3 to 3 m^3. Calculate the following quantities:

$\Delta T =$ ________________________

$\Delta U =$ ________________________

$Q =$ __________________________

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

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

α=__________

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

γ=____________

(c) If a cube of the material in (b) above with a volume V_0=1 m^3 is heated from 0 ^{0}C to 100 ^{0}C, calculate the work done when it expands against a constant pressure of P=1x10^5 Pa.

W=_____________

(d) Suppose the material in (b) above has a mass of 800 kg and a specific heat of c_p=2 J/(kg ^{0}C). Calculate the heat supplied to the system.

Q=_____________

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

ΔU=_______________

(f) Suppose a material has a specific heat that varies as $c=c_0 T$ where c_0 is a constant with SI units of J/(kg K^2) and T is temperature in Kelvin. If $c_0=10\,\text{J}/(\text{Kg K}^2)$, find the heat required to change the temperature of 1 kg of this material from 200 K to 300 K.

Q=________________

[3] A heat engine is reported to operate with 25 % efficiency when the cold reservoir is at 0^0 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 5J. Calculate the heat rejected by this engine.

Q_C=____________________

[4] For water, $\rho=1x10^3$ kg/m^3, $L_f=3.33x10^5$ J/kg and c=4186 J/Kg ^{0}C.
(a) If 4 kg of water at 0^{0}C is mixed with 1 kg of water at 80^{0}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.
ΔS=_____________________
(c) If a 5 kg mass of ice at 0^{0}C melts to become water at 0^{0}C, calculate the change in entropy of the system.
ΔS=_____________________
(d) Suppose a ball of density $\rho_b=8x10^2$ kg/m^3 is floating in water. How much of the volume of the ball is below water?
V_s=__________ m^3