

**Instructions: You have a total of 55 minutes to complete this test. Answer each question completely.**

Time Start \_\_\_\_\_ Time finish \_\_\_\_\_ pledged \_\_\_\_\_

**You must supply all details that led to your answer and correct SI units where required.**

(1) An ideal 3 dimensional **monoatomic** gas with  $c_v = \frac{3}{2}R$  has the equation of state  $PV = nRT$  where  $n$  is the number of moles and  $R=8.314 \text{ J/(K mol)}$ . Suppose that  $n=1$  mole of this ideal gas goes through an **isovolumeric** ( $V=\text{constant}$ ) process. If the change in pressure is  $\Delta P=1 \times 10^5 \text{ Pa}$ , and the change in temperature is  $\Delta T=300\text{K}$ , answer the following using correct SI units.

(a) what is the initial volume of the gas if the initial pressure is  $P=1 \times 10^5 \text{ Pa}$  and the initial temperature is  $T=500\text{K}$ ?

(b) what is the change in internal energy of the gas?

(c) how much heat was supplied (or evolved) from the gas?

(d) If the gas went through an isobaric process ( $P=\text{constant}=1 \times 10^5 \text{ Pa}$ ) instead with the change in temperature still being  $\Delta T=300\text{K}$ , what would be the change in internal energy of the gas?

(2) An ideal diatomic 3 dimensional gas with an initial volume of  $1\text{m}^3$  is initially at a temperature of  $T=300\text{K}$ . You may assume that  $c_v = \frac{7}{2}R$ , which you will need in order to calculate  $\gamma$ .

(a) Calculate  $\gamma$  for this gas.

(b) If the gas increases its temperature **adiabatically** to a temperature of  $600\text{K}$ , what was the final volume of the gas?

(3) A heat engine is observed to operate with 35% efficiency when a heat input of  $Q_H=100\text{J}$  is provided.

(a) What is the work that was measured from this engine?

(b) Suppose the engine went through a Carnot cycle with a rejected source which has a temperature of  $T_c=300^\circ\text{C}$ . What is the temperature of the input reservoir?

(c) Suppose an inventor wants you to loan money for an engine which he says is up to 84% efficient between the temperature extremes of  $500^\circ\text{C}$  and  $75^\circ\text{C}$ . Should you invest in this project? Note: saying just yes or no here is not sufficient; your answer needs to be based upon physics with your work shown.

(4) A metal cube with a density of  $7000\text{ kg/m}^3$  has a coefficient of linear expansion of  $4.5 \times 10^{-6} / ^\circ\text{C}$  and a specific heat of  $200\text{ J}/(\text{kg } ^\circ\text{C})$ . Suppose a  $1\text{ Kg}$  block of the metal is heated from a temperature of  $0^\circ\text{C}$  to a temperature of  $100^\circ\text{C}$ .

(a) What is the change in volume of the cube?

(b) How much heat is added to the system if this expansion was in the presence of an atmosphere of  $P=1 \times 10^5\text{ Pa}$ ?

(c) If this expansion was in the presence of a pressure of  $1 \times 10^5\text{ Pa}$ , how much work was done by the cube?

(d) What was the change in internal energy of the cube?