Principles of Physics I
PHY1321/31AB
MIDTERM 1
Fall2017 Oct 14

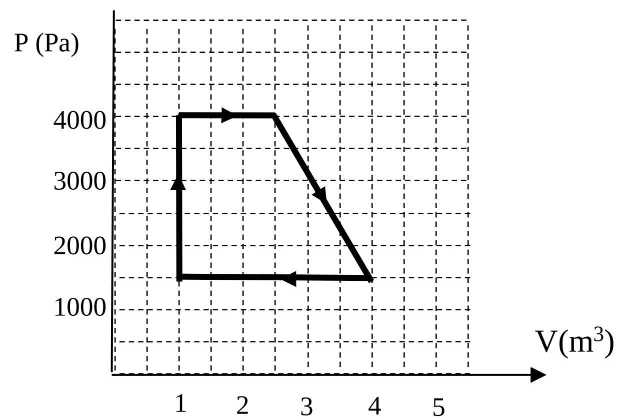
CLOSED BOOK TEST
TIME: 100minutes

Part 1. In the scantron sheet to answer all MC questions below. (Best 6 count towards 48% of your test mark)

1 Short Finned Pilot Whale can dive to depths of 1.1 kilometers. What is the total pressure they experience at this depth? (ϱ = 1020 kg/m^3 and 10^5 N/m^2 = 1 ATM, g=9.81m/s^2.)

a. 9 ATM b. 111 ATM c. 198 ATM d. 297 ATM e. 302 ATM

2 A reversible heat engine has a pV diagram shown on the graph. The net heat transferred between the engine and environment in one cycle is approximately:



a) 0 kJ b) 5.6kJ c) 6.9kJ
d) 7.5kJ e) 8.2kJ

3. A heat pump has a coefficient of performance 5.0. How much heat is exhausted to the hot reservoir when 400kJ of heat are removed from the cold reservoir?

a)500kJ b) 500kJ c) 400kJ
d) 80kJ e) none of the above

4 Given is the two –dimensional gas made out of diatomic molecules. At sufficiently high temperatures the gas molecules are free to move around within the two dimensional plane, as well as to rotate and oscillate. Which of the following pairs correctly represents the average energy of single molecule E_{avg}; and the C_v of the gas at the very low temperatures (T<100K).

a) $E_{avg} = ½mv_x^2 + ½\ mv_y^2$ C_v= R
b) $E_{avg} = ½mv_x^2 + ½\ mv_y^2 + ½I\omega^2$ C_v= 3/2R
c) $E_{avg} = ½mv_x^2 + ½\ mv_y^2 + ½I\omega^2$ C_v= 2R
d) $E_{avg} = ½mv_x^2 + ½\ mv_y^2 + ½I\omega^2 + ½kr^2 + ½\ mv_{osc}^2$ C_v= 5/2R
e) $E_{avg} = ½mv_x^2 + ½\ mv_y^2 + ½\ I_1\omega_1^2 + ½\ I_2\omega_2^2 + ½kr^2 + ½mv_{osc}^2$ C_v= 3R

5 In an isovolumetric process
a) the internal energy is constant.
b) there is no work transferred between the system and its surroundings.
c) no heat is transferred between a system and its surroundings.
d) work and heat are both transferred between the system and its surroundings.
e) none of the above is correct statement about the isovolumetric process

6. 1 mole of gas in a container expands at a constant temperature of 500K. Find the heat delivered to the gas if the initial volume is 5 liters and the final volume is 10 liters.
A) 0 B) 2880 C) 5760 D) 8640 E) none of the above

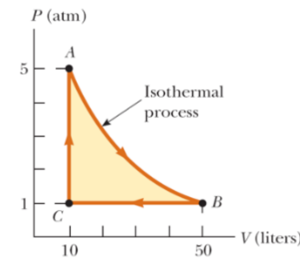
7 The air in an automobile engine at 20°C is compressed from an initial pressure of 1.0 atm and a volume of 200 cm^3 to a final volume of 50 cm^3. Find the final temperature of the air, if the it behaves like an ideal gas (γ= 1.4) and the compression is adiabatic.

a) 237°C b) 285°C c) 463°C d) 510°C e) none of the above

PART 2 **In examination booklets solve 4 out of 5 problems below. Each question has the same weight. (13p)**
For full marks you need a neat diagram (when applicable) and all steps to be clearly demonstrated.

1. **A)** A rigid tank having a volume of 0.100 m^3 contains helium gas at 150 atm. How many balloons can be inflated by opening the valve at the top of the tank? Each filled balloon is a sphere 0.200 m in diameter at an absolute pressure of 1.20atm. (8p)

b) A 1.00-mol sample of an ideal monatomic gas is taken through the cycle shown. The process *A* → *B* is a reversible isothermal expansion. Calculate (a) the net work done by the gas, (b) the energy added to the gas by heat, (c) the energy exhausted from the gas by heat, and (d) the efficiency of the cycle.



2 A copper rod in a form of cylinder of radius 1cm and length of 1m is taken from a forge at 800°C and dropped into 4.00 kg of water at 10.0°C. Assuming that no energy is lost by heat to the surroundings, determine:

a) final equilibrium temperature of the system. (8p)
b) the change of the length of the copper rod as result of its temperature change. (2p)
c) the power radiated by the copper rod just before it was dropped into the water. (3p)

density of Cu = 8.96g/cm^3 α(Cu) = $17 \cdot 10^{-6}$ K^{-1} c(Cu)=385 J/(kgC) A(cylinder)= $2\pi Rh+2\pi R^2$
The specific heat of water/ice/steam as well as latent heats are given on the formula sheet.

3 A sample of diatomic gas with specific heat ratio γ= 5/3, confined to a cylinder of initial volume of 20 liters, is carried through a closed cycle. The gas is initially at 1.00 atm and at 243K. First, its pressure is doubled under constant volume. Then, it expands adiabatically three times the original volume. Then the gas is cooled down at constant volume to of 0.16 of the original pressure. Finally, the gas is compressed adiabatically i to its original volume.and pressure.

a) Draw a *PV* diagram of this cycle. (2p)
b) Determine the pressutr of the gas at the end of the adiabatic expansion. (2p)
c) Find the temperature of the gas at the end of the adiabatic expansion. (2p)
d) Find the temperature at the end of the cycle. (2p)
e) What was the net work done on the gas for this cycle? (2p)
f) Find the heat transferred to gas from hot reservuar in one cycle (1p)
g) What would be the efficiency of an engine based on this cycle? (3p)

4 Given is one mole of CO gas at 27 C. (Molar mass of CO is 28g).

a) Use Maxwell Boltzmann distribution to write the case-specific full expression for the number of CO molecules having speeds between 320.5m/s and 321.5m/s. (The expression has to contain data specific for this problem – but there is no need to finish the calculations!) (6P)
b) Find the most probable velocity at this temperature. (2P)
c) At what temperature the average velocity of CO gas molecules would be the same as in part (b)? (3P)
d) Demonstrate that the most probable velocity is indeed equal to v_{MP}= (2 kT/m)^{½} (2P)

5 a) Present detailed proof of the one of the two below: (4P)
i)using the summary of thermodynamic processes table (from your formula sheet) and known Laws of Thermodynamics prove that Cp=Cv+R for ideal gas.
ii) using the summary of thermodynamic processes table (from your formula sheet) and known Laws of Thermodynamics prove that Cp/Cv=γ for ideal gas.

b) Present one of the following proofs below: (9P)
i) Using first principles, show that pV^{γ}=const for adiabatic transformation
ii) Using the Maxwell-Bolzmann Speed Distribution P(v)dv obtain the expression for Boltzmann Energy Distribution Function P(E)dE.