The University of Zambia
Physics Department
Term Test-III June 2015
PHY 1010: Introductory Physics- I

All questions carry equal marks. The marks are shown in brackets. Question 1 compulsory. Attempt three more questions. Clearly indicate on the answer sc... cover page which questions you have attempted.

Time: Two hours. **Maximum marks = 100.**

Write clearly your name, computer number, and tutorial group number on ... answer book.

Wherever necessary use:

g = 9.8 m/s^2 : ρ_{water} = 1000 kg/m^3 : Vol. of sphere = $\frac{4}{3}\pi r^3$: 1 ton = 1000 kg : 1 atm = 1.013 x 10^5 Pa

Some equations you may find useful:

$$\rho = \frac{m}{V} \qquad stress = \frac{F}{A} \qquad strain = \frac{\Delta L}{L_0} \qquad shear-strain = \frac{\Delta L}{L_0} = \phi \qquad Y = \frac{F/A}{\Delta L/L_0} \qquad S = \frac{F/A}{\Delta L/L_0} = \frac{F/A}{\phi}$$

$$P = \frac{F_\perp}{A} \qquad P_G = P_{tot} - P_a \qquad P_G = \rho g h \qquad F_B = \rho \vec{V} g, \text{submerged object} \qquad F_B = Mg, \text{floating M}$$

$$B = \frac{\Delta P}{\Delta V/V_o}$$

$Q/t = e\sigma AT^4$ $\quad Q/\Delta t = (kA\Delta T)/\Delta L$ $\quad \Delta Q = mc\Delta T = nC\Delta T$ $\quad \Delta L = \alpha L_o \Delta T$

$\Delta V = \beta V_o \Delta T$ $\quad \Delta W = P\Delta V$ $\quad \Delta W = nRT.ln(V_f/V_i)$ $\quad C_p = C_v + R$

$C_v = \frac{3}{2}R$ $\quad PV = nRT$ $\quad P_1V_1^\gamma = P_2V_2^\gamma$ $\quad T_1V_1^{\gamma-1} = T_2V^{\gamma-1}$

$Q = \Delta U + W$ $\quad$ Carnot engine, $e = 1 - T_2/T_1 = \frac{W}{Q_H}$ $\quad C_v = \frac{3}{2}R$

$S = k\ln\Omega$ $\quad \Delta S = Q/T$ $\quad$ Efficiency $= W/Q_h$ $\quad COP_{fridge} = Q_c/W_{in}$

$COP_{heat\ pump} = Q_h/W_{in}$ $\quad COP_{max\text{-}fridge} = T_c/(T_h - T_c)$ $\quad COP_{max\ h.\ pump} : T_h/(T_h - T_c)$

For Question 1, use the blank answer sheet provided.

For other questions, clearly indicate answered questions with centre numbering

Example:

Question 2(b)

DO NOT write the question number in the top left corner of the page, it must ... visible when pages are stapled.

Question 1: Sample answers: F (a), G (d).... etc. For each correct answer, 2.5 marks. For each wrong answer, (0.83) will be deducted. No answer, zero mark. No deduction of marks for not attempting. Minimum total mark for Question 1 is zero. **So don't be afraid to attempt!!** **[10 × 2.5 = 25]**

(A) A Carnot engine that operates between absolute temperatures T_1 and T_2:

(a) is 100% efficient
(b) has an efficiency of T_1/T_2
(c) has the efficiency of a non-reversible engine
(d) has the maximum efficiency possible for the given temperatures

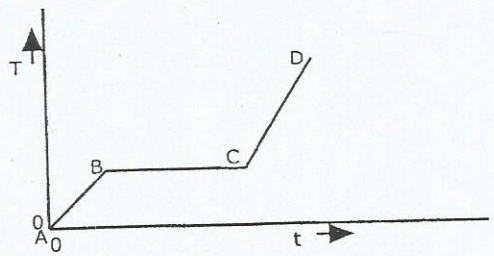
(B) In natural convection a heated portion of fluid moves because:

(a) its molecular motions become aligned
(b) of molecular collisions within it
(c) of molecular vibrations about the equilibrium
(d) its density is less than that of the surrounding fluid

(C) In an adiabatic process there is no

(a) temperature change
(b) work done
(c) heat exchanged
(d) internal energy change

(D) A substance is heated at a constant rate. The sketch shows the variation of temperature T with time t of the substance. In which segment or segments of the graph must be more than one phase of the substance?



(a) AB and CD
(b) AB only
(c) BC only
(d) AB, BC and CD

(E) At constant temperature the pressure and volume are:

(a) constant
(b) inversely proportional
(c) directly proportional
(d) independent of one another

(F) Linear thermal expansion has a meaning for:

(a) all fluids
(b) solids
(c) gases only
(d) solids and liquids

(G) An object is submerged in water. The buoyant force acting on the object:

(a) depends on the mass of the object
(b) is equal to the weight minus the volume of the object
(c) is independent of the object's size
(d) is equal to the weight of the water displaced

(H) A modulus of elasticity is the ratio of:

(a) strain to stress
(b) stress to deformation
(c) stress to strain
(d) change in length to original length

(I) Melting, boiling, condensing, subliming are processes known as:

(a) adiabatic processes
(b) fusion
(c) calorimetry
(d) phase changes

(J) A fire place or an electric heater heats a room mainly by:

(a) conduction
(b) convection
(c) diffusion
(d) radiation

Attempt any three full questions from the following:
e.g. Q3 (a), (b), and (c) is one question:

Q 2 (a) What is the minimum amount of ice at -15 ^{0}C that must be added to 600 water at 19 ^{0}C in order to bring the temperature down to 0^{0}C?
(c_{ice} = 2.09 kJ/kg.^{0}C, H_f = 335 kJ/kg)

(b) The efficiency of a Carnot engine is 47%. If the temperature of the cold reser is lowered by 55 ^{0}C the efficiency improves to 58%. Find the temperatures o cold and the hot reservoirs. [1

(c) A liquid has a volume of 400 cm^3 at -10 °C. When the liquid is heated to 11 its volume increases by 23.28 cm^3. Calculate the coefficient of volume expa of this liquid. [5

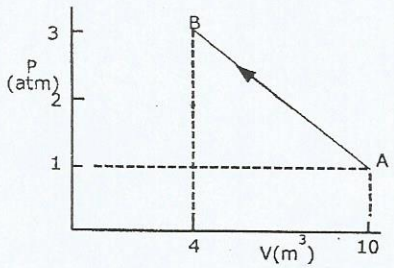
Q 3 (a) A piston and cylinder system containing 60 cm^3 of a diatomic gas at 20 ^{0}C and 100 kPa pressure is suddenly (i.e. adiabatically) compressed to 2 cm^3. What are its new pressure and temperature? ($\gamma = 1.4$) **[11]**

(b) A thin spherical shell of mass 0.5 kg and diameter 0.22 m is filled with alcohol (density = 806 kg/m^3). It is released from rest at the bottom of a pool of water. Find the acceleration of the alcohol-filled shell as it rises to the surface of the pool. **[9]**

(c) A copper rod has a length of 1.5 m and cross-sectional area of 4×10^{-4} m^2. One end is in contact with boiling water at 1 atm and the other with a mixture of ice and water.

What is the mass of ice per second that melts? Assume that no heat is lost through the side surface of the rod? (Thermal conductivity for copper is 390 J/s.m.°C and heat of fusion for water is 335 kJ/kg) **[5]**

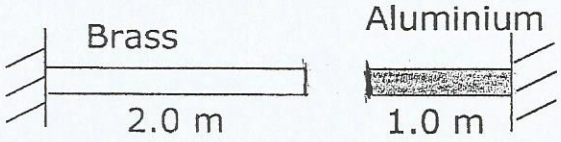
Q 4 (a) As shown on the PV diagram below, 0.4 kmol of a monatomic ideal gas is taken from state *A* to state *B* in a straight line. Calculate *W*, ΔU and ΔQ for the thermodynamic process. **[10]**



(b) A heat pump has a COP of 3.5 and is rated to do work at 2000 W.

i) How much heat can it add to a room per second?
ii) If the pump is reversed to act as an air-conditioner in summer, what would the coefficient of performance be, assuming all else remains the same? **[8]**

(c) The 2.0 m long brass bar and 1.0 m long aluminium bar in the diagram below are each attached to an immovable wall. At a temperature of 28 °C the air gap between the two bars is 1.3×10^{-3} m. At what temperature will the gap just be closed given that the coefficient of thermal expansion for brass is 10×10^{-6}/°C and for aluminium is 25×10^{-6}/°C? **[7]**



$Q = \Delta U + W$ $\quad W = PV$ $\quad \Delta W = nRT\left(\frac{V_f}{V_i}\right)$

$W = Q - \Delta U$

Q 5 (a) A steam engine operates with steam drawn at 150 °C and exhausted to the surroundings at a temperature of 20 °C. The efficiency of the engine is 60% that of an ideal Carnot engine operating between the same two temperatures.

i) Calculate the actual efficiency of the engine, and
ii) What should be the temperature of the steam so that the actual efficiency of the steam engine is 30%? Assume all factors remain the same. **[9]**

(b) How deep is a pond if bubbles forming at the bottom grow 4 times in size in rising to the top? The temperature at the bottom is at 10 °C, and that at the surface of the pond is 20 °C. **[9]**

(c) Water is confined in a strong container by means of a piston with cross sectional area of 0.50 cm^2. How large a force on the piston is required to increase the density of water by 0.01 percent? (Bulk modulus water = $2.2 \times 10^9 N/m^2$) **[7]**

-END OF TEST 3-