Seat No.

King Mongkut's University of Technology Thonburi
Midterm Examination in Academic Year 2/2014

Subject: PHY 207 Thermal and Statistical Physics **Student: Physics Students**
Date: 25th February 2015 **Time: 9.00 – 12.00 a.m.**

Name :……………………………………………Identification No……………………….

Instructions:
1. This examination consists of 10 questions (3 pages, including the cover page).
2. Total score for this paper is 50 points.
3. The total time allowed for this examination is 3 hours (9.00 am – 12.00 am)
4. This is "Closed book examination".
5. Use of an approved calculator is allowed.
6. You must answer the questions in the answer notebook provided.
7. Do not forget to fill in your name and your information in the space provided.

หมายเหตุ ห้ามนำหนังสือหรือเอกสารเข้าห้องสอบ ห้ามนำข้อสอบออกนอกห้องสอบ
อนุญาตให้นำเครื่องคิดเลขที่ถูกต้องตามระเบียบของมหาวิทยาลัยเข้าห้องสอบได้
(มีสูตรหรือสมการที่จำเป็นให้ไว้ในหน้าที่ 3 ของข้อสอบ)

Nakarin Pattanaboonmee
Examiner

No.	Full points	Earned points
1	16	
2	4	
3	4	
4	6	
5	4	
6	2	
7	3	
8	2	
9	4	
10	5	
Total	50	

This examination has been approved by the committee of physics department.

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Name...Student ID..............

Midterm Examination (2/2014)

PHY 207: Thermal and Statistical Physics

1. Describe briefly (a) The zeroth law of thermodynamics. *(2 points)*

   (b) Internal energy and the first law of thermodynamics. *(2 points)*

   (c) Entropy and the second law of thermodynamics. *(2 points)*

   (d) Coefficient of thermal expansion and Compressibility. *(2 points)*

   (e) Thermodynamic equilibrium state. *(2 points)*

   (f) Enthalpy and specific heat capacity. *(2 points)*

   (g) Basic principle of constant-volume gas thermometer. *(2 points)*

   (h) The Gay-Lussac-Joule experiment. *(2 points)*

2. (2.1) If an ideal gas undergoes an isothermal expansion at pressure P, during which its volume changes from V_a to V_b. How much work does the gas do? *(2 points)*

   (2.2) If a gas with the equation of state as $P(v-b)=RT$,undergoes an isothermal expansion at temperature T, during which its volume changes from V_a to V_b. How much work does the gas do? *(2 points)*

3. Suppose that 5.0 kg of water at 90 °C is cooled to 20 °C, the temperature of the surrounding room. The specific heat capacity at constant pressure of water is 4180 J kg^{-1} K^{-1}. Find the changes in entropy of the water, the surroundings and universe. Are your answers consistent with the second law of thermodynamics? *(4 points)*

4. Using the Dieterici equation of state, $P=\dfrac{RT}{v-b}e^{-a/RTv}$, show that

   $$v_c = 2b, T_c = \frac{a}{4Rb}, P_c = \frac{a}{4e^2b^2} \quad \textit{(6 points)}$$

   Hint: $\left(\dfrac{\partial P}{\partial v}\right)_T = 0$ *and* $\left(\dfrac{\partial^2 P}{\partial v^2}\right)_T = 0$ *at critical point.*

5. Write down and explain briefly the P-V diagram and S-T diagram of a Carnot cycle. *(4 points)*

6. Find the expansivity (β) and the compressibility (κ) of an ideal gas. *(2 points)*
7. Please write down your design of Sterling engine and explain how it works. *(3 points)*
8. Prove that the specific work in a reversible adiabatic expansion of an ideal gas: $w = (P_2 v_2 - P_1 v_1)\dfrac{1}{1-\gamma}$. *(2 points)*
9. A heat engine operates on a Carnot cycle with an efficiency of 70 percent. What coefficient of performance (COP) would a refrigerator operating on the same cycle have? The low temperature is 0 °C. *(4 points)*
10. A bubble of 1.00 mole of (monatomic) helium is submerged at a certain depth in liquid water when the water (and thus the helium) undergoes a temperature increase ΔT of 20.0 °C at constant pressure. As a result, the bubble expands. How much heat Q is added to the helium during the expansion and temperature increase? How much work W is done by the helium as it expands against the pressure of the surrounding water during the temperature increase? *(5 points)*

<u>Important Formulas</u>

Ideal gas: $PV = nRT$ or $Pv = RT$,where R = 8.3143x10³ J kilomole⁻¹ K⁻¹

Ven der Waals: $\left(P + \dfrac{a}{v^2}\right)(v - b) = RT$ or $Pv^3 - (Pb + RT)v^2 + av - ab = 0$

$$\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \qquad \kappa = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T \qquad \gamma = \frac{C_P}{C_V} \qquad h = u + Pv$$

If $f(x,y,z) = 0$ then $\left(\dfrac{\partial X}{\partial Y}\right)_Z = \dfrac{1}{\left(\dfrac{\partial Y}{\partial X}\right)_Z}$ and $\left(\dfrac{\partial X}{\partial Y}\right)_Z \left(\dfrac{\partial Y}{\partial Z}\right)_X \left(\dfrac{\partial Z}{\partial X}\right)_Y = -1$.

Adiabatic process: $Pv^{\gamma} =$ constant; $Tv^{\gamma-1} =$ constant; $TP^{\frac{1-\gamma}{\gamma}} =$ constant

Heat engine: $\eta = \dfrac{W}{Q_2} = \dfrac{Q_2 - Q_1}{Q_2}$ Refrigerator: $\text{COP} = \dfrac{Q_1}{W} = \dfrac{Q_1}{Q_2 - Q_1}$