103 學年第一學期 普通物理 B 期末考試題

[Wolfson Ch. 15-19]　2015/01/13, ***8:20AM – 09:50AM***

B

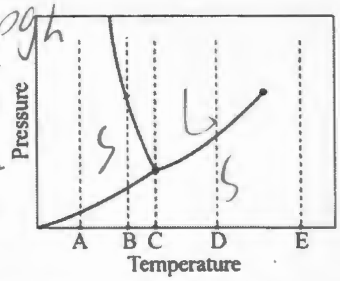
(i)答案卷第一張正面為封面。第一張正、反兩面<u>不要寫任何答案</u>。

(ii)依空格號碼順序在第二張<u>正面</u>寫下所有填充題答案，不要寫計算過程。

(iii)依計算題之題號順序在第二張<u>反面</u>以後寫下演算過程與答案，<u>每題從新的一頁寫起</u>。

Note: $k = 1.38 \times 10^{-23}$ J/K, $R = 8.314$ J/K, $\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4, 1 cal = 4.184 J.

Part I. Filling the blank (4 points per blank)



• The phase diagram for water is shown in the figure. As the pressure is increased, which point will experience solid-liquid phase transition? 【1】

• Usually, the water source of an apartment building is the water tower on top of the building. If the height difference between the tap at the first floor and the tap at the fifth floor is 12.0 m and the water tower is 4.0 m higher than the tap at the fifth floor, we can calculate the water speed at the fifth floor v_5 and the water speed at the first floor v_1. Then $v_5 - v_1 =$ 【2】 m/s.

• A cylinder of volume V contains n moles of compressed gas at temperature T. If the cylinder is discharged into a vacuum chamber of volume mV and its temperature remains unchanged, how much energy has become unavailable to do work? 【3】.

• In a diesel engine, the compression of engine volume is fast enough that the process is essentially adiabatic. The specific heat ratio of the gas in the engine is 5/3 and the compression ratio $V_{max}/V_{min} = 8.00$. Assume before compression the gas is at 20.0 °C, the ignition temperature is 【4】 °C.

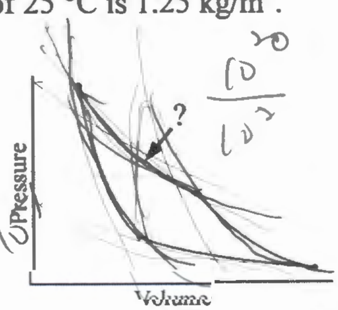
• Two identical atoms are confined in a two-dimensional space and react to form a diatomic molecule. If the molecule has translational and rotational motions, the degree of freedom of the molecule is 【5】.

• The relationship of an object's heat capacity C and its absolute temperature T is $C = aT^n$, where a is a constant. When the object is heated from T_1 to T_2, the entropy change is 【6】.

• Describe the first law of thermodynamics. Note that you have to comment in detail on each symbol you use in the description. 【7】.

• The surface temperature of our Sun is 5.80×10^3 K and the solar radius is 6.96×10^8 m. The average distance between Earth and Sun is 1.50×10^{11} m. Assuming the Sun is a blackbody (emissivity = 1), the mean solar radiation power received at Earth is 【8】 W/m^2.

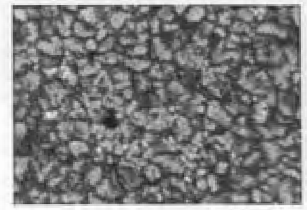
• A hot-air balloon has a volume of 2500 m^3. The density of air at a temperature of 25 °C is 1.25 kg/m^3. The density of the hot air inside the balloon at a temperature of 100 °C is 0.95 kg/m^3. If the mass of balloon is 200 kg, the maximum total mass of the passengers is 【9】 kg.



• A refrigerator takes a Carnot cycle shown in right figure. What is the operating direction, counterclockwise or clockwise? 【10】. What is the process indicated in the figure? 【11】.

• The average speed of a hydrogen atom (mass = 1.66×10^{-27} kg) at Sun surface (temperature = 5.80×10^3 K) is 【12】 m/s.

• A candy bar contains 350 Calories. If the amount of energy equivalent to this candy bar is used to lift a 65 kg person off the ground. How high can this person being lifted? 【13】 m.



• The close-up picture of the solar surface is shown in right figure. From this image, we can speculate that the heat generated by the nuclear reactions in the interior of the Sun is transferred to the surface most effectively by (a) conduction (b) convection or (c) radiation? 【14】.

• To achieve the same factor of heat insulation, what is the thickness of Styrofoam if we replace the 15-cm thick concrete wall of a house with Styrofoam of the same surface area? (the thermal conductivity of concrete and Styrofoam is 1.0 and 0.029 W/m^2·K^4, respectively.) 【15】 m.

• We mix three bottle of different liquid with equal mass. If their specific heat capacity is 0.60 cal/g·°C, 0.30 cal/g·°C, and 0.20 cal/g·°C, and their temperature is 80.0°C, 30.0°C, and 20.0°C. The temperature of the mixed fluid is 【16】 °C.

$m \times 0.6 \times (T-80) + m \times 0.3 \times (T-30) + m \times 0.2 \times (T-20) = 0$

$0.6T - 48 + 0.3T - 9 + 0.2T - 4 = 0$

$1.1T = 61$

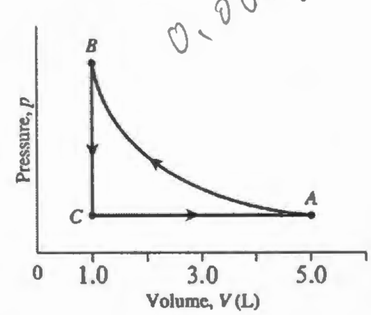
Part II Problems (10 points per problem)

1.

A glass beaker (燒杯) holds 20.0 L at 20.0 °C. It's filled to the brim with mercury (Hg) at 20 °C. If the temperature now increases to 30.0 °C, (a) how much does the glass beaker's volume increase? (b) How much mercury spills out? The linear expansion coefficient of glass is 3.2 × 10^{-6} (K^{-1}) and volume expansion coefficient of mercury is 18 × 10^{-5} (K^{-1}).

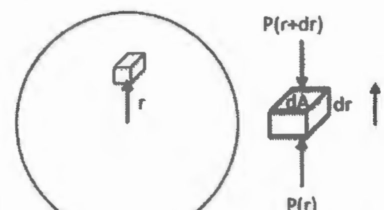
$9.6 \times 10^{-6} = \frac{\Delta V / V}{\Delta T}$ 0.00192

2.



An ideal gas with γ = 7/5 undergoes the cyclic process ABCA shown in right figure, where AB, BC, and CA are adiabatic, constant-volume, and isobaric processes, respectively. The pressure at A is 62 kPa. Find (a) the pressure at B and (b) the net work done by the gas.

3.



Similar to the derivation of the hydrostatic equilibrium equation on Earth, we can derive the pressure gradient $dP(r)/dr$ inside the Sun by balancing the forces on a fluid element of area dA, thickness dr, and mass dm at radius r. Show your answers with the variables shown in the figure, the density at radius r, $\rho(r)$, and the mass within radius r, $M(r)$.

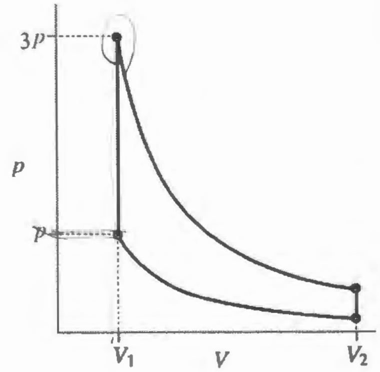
(a) What is the upward force the fluid element experience? (2 points)

(b) What is the magnitude of the gravitational force on the fluid element? (3 points)

(c) What is the inward force the fluid element experience? (2 points)

(d) Derive $dP(r)/dr$. (3 points)

4.



An engine (outputs positive work) with ideal gas of specific heat ratio γ operates on a cycle which consists of two adiabatic and tow constant-volume segments, as shown in the figure. (a) Find the maximum temperature in terms of the minimum temperature T_{min} and compression ratio V_2/V_1. (b) Find the engine's efficiency in terms of compression ratio V_2/V_1.