UNIVERSITI SAINS MALAYSIA

Final Examination
Academic Session 2007/2008

April 2008

JIK 217 – THERMODYNAMICS
[JIK 217 – TERMODINAMIK]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains EIGHT printed pages before you begin the examination.

Answer **FIVE** questions. You may answer **either** in Bahasa Malaysia or in English.

All answers must be written in the answer booklet provided.

Each questions is worth 20 marks and the marks for each sub question is given at the end of that question.

Sila pastikan bahawa kertas peperiksaan ini mengandungi LAPAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.

*Jawab **LIMA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.

Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.

1. A spring is placed in a large thermostat at a constant temperature of 27°C and stretched isothermally and reversibly ten times from its equilibrium length. During this process, the spring absorbs 4.184 J of heat. It is then released without any restraining back tension and allowed to retract to its equilibrium initial length. During retraction it releases 14.644 J of heat. Calculate;

(a) The change in entropy for the stretching of the spring.

(6 marks)

(b) The change in entropy for the retraction of the spring.

(6 marks)

(c) The total change in entropy for stretching and retraction of;

(i) the spring
(ii) the thermostat

(8 marks)

Satu spring diletakkan di dalam termostat pada suhu tetap 27°C dan meregang secara isotermal dan berbalik kepada 10 kali ganda daripada panjang asalnya. Semasa proses ini, spring tersebut telah menyerap 4.184 J haba. Spring itu kemudiannya kembali kepada panjang keadaaan asal. Proses pengenduran kembali spring itu kepada keadaan asal menghasilkan sebanyak 14.644 J haba. Kirakan;

(a) Perubahan entropi untuk peregangan spring.

(6 markah)

(b) Perubahan entropi untuk pengenduran spring.

(6 markah)

(c) Perubahan entropi keseluruhan untuk peregangan dan pengenduran bagi;

(i) spring
(iii) termostat

(8 markah)

2. The following data for sulphur have been obtained from K. K. Kelly, 1949, Bulletin of US Bureau of Mines No 746 :-

Sulphur (rhombic) $C_p = 3.58 + 6.24 \times 10^{-3}$ T cal K^{-1} mol^{-1} for temperature 298 to 368.6 K

Sulphur (monoclinic) $C_p = 3.56 + 6.96 \times 10^{-3}$ T cal K^{-1} mol^{-1} for temperature 368.6 K to melting point

Sulphur (liquid) $C_p = 5.40 + 5.00 \times 10^{-3}$ T cal K^{-1} mol^{-1} for melting point to boiling point

Transition temperature from rhombic to monoclinic, 368.6 K
Melting point of monoclinic sulphur, 392 K
Latent heat of transition, 0.086 kcal mol^{-1}
Latent heat of fusion, 0.30 kcal mol^{-1}

Calculate the change in entropy when 1 mol of sulphur is heated from 300 to 410 K.

(20 marks)

Data untuk sulfur berikut diperolehi daripada K.K Kelly, 1949,Buletin of US Bureau of Mines No 746 :-

Sulfur (rombik) $C_p = 3.58 + 6.24 \times 10^{-3}$ *T cal* K^{-1} mol^{-1} *untuk suhu 298 hingga 368.6 K*

Sulfur (monoklinik) $C_p = 3.56 + 6.96 \times 10^{-3}$ *T cal* K^{-1} mol^{-1} *untuk suhu 368.6 K hingga takat lebur*

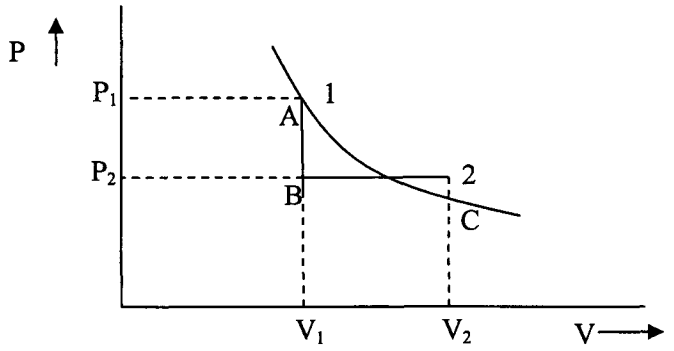
Sulfur (cecair) $C_p = 5.40 + 5.00 \times 10^{-3}$ *T cal* K^{-1} mol^{-1} *untuk takat lebur hingga takat didih*

Peralihan suhu daripada rombik kepada monoklinik, 368.6 K
Takat lebur sulfur monoklinik , 392 K
Haba pendam peralihan, 0.086 kcal mol^{-1}
Haba pendam pelakuran, 0.30 kcal mol^{-1}

Kirakan perubahan entropi apabila 1 mol sulfur dipanaskan daripada 300 kepada 410 K.

(20 markah)

3. Consider 2.0 mol of an ideal gas having a volume $V_1 = 3.50\ m^3$ at a temperature $T_1 = 300\ K$.



This gas is allowed to expand to a new volume $V_2 = 7.0\ m^3$ at a temperature $T_2 = T_1$. The process is carried out (I) isothermally and (II) along the path ABC as shown in the figure. In the process (II), the pressure is allowed to drop at constant volume and the volume increases at constant pressure.

(a) For process (I) calculate the work done by the gas, the quantity of heat added to the gas and the consequent change in the internal energy of the gas.

(10 marks)

(b) For process (II) calculate the work done by the gas, the quantity of heat added to the gas and the consequent change in the internal energy of the gas.

(10 marks)

2.0 mol gas ideal mempunyai isipadu $V_1 = 3.50\ m^3$ pada suhu $T_1 = 300\ K$.

Gas ini mengembang kepada isipadu $V_2 = 7.0\ m^3$ pada suhu $T_2 = T_1$. Proses ini berlaku secara (I) isothermal dan (II) sepanjang laluan ABC seperti yang ditunjukkan dalam gambarajah di atas. Dalam proses (II), tekanan menurun pada isipadu tetap dan isipadu meningkat pada tekanan tetap :

(a) Bagi proses (I) kirakan kerja yang dilakukan oleh gas, kuantiti haba yang ditambah pada gas dan perubahan yang disebabkan oleh tenaga dalaman gas.

(10 markah)

(b) Bagi proses (II) kirakan kerja yang dilakukan oleh gas, kuantiti haba yang ditambah pada gas dan perubahan yang disebabkan oleh tenaga dalaman gas.

(10 markah)

4. (a) A refrigerator having a coefficient of performance one–half that of a Carnot refrigerator is operated between reservoir at temperatures of 200 and 400 K. It absorbs 600 J from the low temperature reservoir. Calculate the amount of heat rejected to the high-temperature reservoir.

(8 marks)

(b) A refrigerator operating at 30°C is employed to maintain a cold storage tank at −10°C. What is the minimum amount of work required to withdraw 4.184 kJ from the tank?

(7 marks)

(c) A freezer is kept in an ambient temperature of 300 K. In order to maintain the temperature of the freezer box at 240 K, heat is to be removed from it at 1250 Js^{-1}. Calculate the maximum coefficient of performance of this freezer.

(5 marks)

(a) Sebuah peti sejuk (refrigerator) mempunyai keupayaan koefisien satu setengah daripada peti sejuk Carnot dan reservoir beroperasi antara suhu 200 dan 400 K. Ia menyerap 600 J daripada reservoir bersuhu rendah.Kirakan jumlah haba yang disingkirkan kepada reservoir bersuhu tinggi.

(8 markah)

(b) Sebuah peti sejuk (refrigerator) beroperasi pada 30°C untuk menstabilkan suhu tangki penyimpan sejuk pada −10°C. Berapakah jumlah kerja minimum yang diperlukan untuk mengeluarkan 4.184 kJ daripada tangki?

(7 markah)

(c) Sebuah penyejukbeku (freezer) berada pada suhu ambien 300 K. Untuk menstabilkan suhu kotak penyejukbeku pada 240 K, haba hendaklah disingkirkan daripadanya sebanyak 1250 Js^{-1}. Kirakan keupayaan maksimum koefisien penyejukbeku ini.

(5 markah)

5. One mole of an ideal gas with $C_{v,m}$ = 5/2 R undergoes the transformations described in the following list from an initial state described by T = 250 K and P = 1.00 bar. Calculate q, w, ΔH, ΔU and ΔS for each process.

(a) The gas undergoes a reversible adiabatic expansion until the final pressure is half its initial value.

(6 marks)

(b) The gas undergoes an adiabatic expansion against a constant external pressure of 0.500 bar until the final pressure is half its initial value.

(6 marks)

(c) The gas undergoes an expansion against a constant external pressure of zero bar until the final pressure is equal to half of its initial value.

(8 marks)

1 mol gas ideal dengan $C_{v,m}$ = 5/2 R melalui perubahan seperti yang diterangkan di dalam senarai di bawah daripada keadaan awal T = 250 K dan P = 1.00 bar. Kirakan q, w, ΔH, ΔU dan ΔS pada setiap proses.

(a) Gas melalui pengembangan adiabatik berbalik sehinga tekanan akhir adalah separuh daripada nilai awalnya.

(6 markah)

(b) Gas melalui pengembangan adiabatik terhadap tekanan luar tetap 0.500 bar sehingga tekanan akhir adalah separuh daripada nilai awalnya.

(6 markah)

(c) Gas melalui pengembangan terhadap tekanan luar tetap (0 bar) sehingga tekanan akhir adalah sama dengan separuh daripada nilai awalnya.

(8 markah)

6. Consider the first-order decomposition of cyclobutane at 438 °C at constant volume :-

$$C_4H_8\ (g) \longrightarrow 2\ C_2H_4\ (g)$$

(a) Express the rate of the reaction in terms of the change in total pressure as a function of time.

(5 marks)

(b) The rate constant for the reaction is $2.48 \times 10^{-4}\ s^{-1}$. What is the half life?

(6 marks)

(c) After initiation of the reaction, how long will it take for the initial pressure of C_4H_8 to drop to 90% of its value?

(9 marks)

Pertimbangkan tertib pertama penguraian siklobutena pada suhu 438 °C dengan isipadu tetap :-

$$C_4H_8\ (g) \longrightarrow 2\ C_2H_4\ (g)$$

(a) Tunjukkan kadar tindakbalas ini dari segi perubahan dalam tekanan total sebagai fungsi masa.

(5 markah)

(b) Kadar tetap tindakbalas adalah $2.48 \times 10^{-4}\ s^{-1}$. Kirakan separuh hayatnya.

(6 markah)

(c) Selepas tindakbalas bermula berapa lamakah masa yang diambil untuk tekanan awal C_4H_8 menurun kepada 90% daripada nilainya.

(9 markah)

EQUATIONS AND CONSTANTS

Constant

$R = 1.9872 \text{ cal mol}^{-1} \text{ K}^{-1} = 8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$

$= 0.082057 \text{ atm L mol}^{-1} \text{ K}^{-1} = 0.083145 \text{ bar L mol}^{-1} \text{ K}^{-1}$

$= 8.3145 \text{ Pa m}^3 \text{ mol}^{-1} \text{ K}^{-1} = 62.364 \text{ torr L mol}^{-1} \text{ L}^{-1}$

$0^\circ\text{C} = 273.15 \text{ K}$

Equations

For a (monatomic) ideal gas $P = nRT/V$ $C_p = 5/2\ R$ $C_v = 3/2\ R$

For a Van Der Waals gas $P = \frac{nRT}{V-nb} - \frac{n^2a}{V^2}$

Coefficient of performance $\eta_r = T_{cold} / T_{hot} - T_{cold}$

$\eta_{hp} = T_{hot} / T_{hot} - T_{cold}$

Work $= -\int PdV$

$= -nRT \text{ In } V_2/ V_1$ (expansion)

$= -nRT \text{ In } V_1/ V_2$ (compression)

- oooOooo -