UNIVERSITI SAINS MALAYSIA

Final Examination
2016/2017 Academic Session

May/June 2017

JIF 314 – Thermodynamics
[Termodinamik]

Duration : 2 hours
[Masa : 2 jam]

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

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

In the event of any discrepancies, the English version shall be used.

Read the instructions carefully before answering.

Each question carries 100 marks.

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

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

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Baca arahan dengan teliti sebelum anda menjawab soalan.

Setiap soalan diperuntukkan 100 markah.

Table of Constants:

R = 8.315 J/mol·K

1. (a) Define

(i) heat.

(ii) work.

(iii) internal energy.

(iv) Zeroth law.

(v) First Law of thermodynamics.

(60 marks)

(b) Explain briefly the following processes:

(i) adiabatic process.

(ii) isobaric process.

(iii) isothermal process.

(iv) quasi-static process.

(40 marks)

2. A functional relationship among three independent coordinates (x, y, z) such that $f(x, y, z,) = 0$. Taking x as a function of y and z, the exact differential, dx, in terms of partial derivatives with respect to y and z is given by

$$\mathrm{d}x = \left(\frac{\partial x}{\partial y}\right)_z \mathrm{d}y + \left(\frac{\partial x}{\partial z}\right)_y \mathrm{d}z\,.$$

(a) Write down the exact differential, dy in terms of partial derivatives with respect to x and z.

(20 marks)

(b) Using the answer in (a) and the given expression of dx, show that

$$\mathrm{d}x = \left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial x}\right)_z \mathrm{d}x + \left[\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x + \left(\frac{\partial x}{\partial z}\right)_y\right]\mathrm{d}z$$

(20 marks)

(c) Based on the equation shown in (b), argue how you would obtain the relation $\left(\frac{\partial x}{\partial y}\right)_z = \frac{1}{\left(\frac{\partial y}{\partial x}\right)_z}$

(20 marks)

(d) Based on the equation shown in (b), argue how you would obtain the relation $\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x + \left(\frac{\partial x}{\partial z}\right)_y = 0$

(20 marks)

(e) Based on the relations in (a) to (d), show

$$\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$$

(20 marks)

3. (a) Define heat capacity C_P at constant pressure.

(15 marks)

(b) Define heat capacity C_V at constant volume.

(15 marks)

(c) How is C_V of an ideal gas be related to the internal energy function, U?

(15 marks)

(d) For an ideal gas, which type of heat capacity, C_P or C_V, has a larger numerical value?

(15 marks)

(e) Explain your answer in (d) qualitatively.

(15 marks)

(f) For an ideal gas, what is the difference between C_P and C_V, $C_P - C_V$?

(15 marks)

(g) Prove that the work done by an ideal gas with constant heat capaticites during a quasi-static adiabatic expansion is equal to $W = -C(T_i - T_f)$.

(10 marks)

4. (a) Starting from the First Law of thermodynamics and ideal gas equation, where both undergo an infinitesimal quasi-static process, show that

$$C_p = C_v + nR$$

(30 marks)

(b) One mole of a gas obeys the van der Waals equation of state:

$$\left(P + \frac{a}{v^2}\right)(v - b) = RT ,$$

and its molar internal energy is given by

$$u = cT - \frac{a}{v},$$

where a, b, c and R are constants.

Calculate the molar heat capacities c_v and c_P, in terms of a, b and c.

(70 marks)

***Table of Constants*:**

R = 8.315 J/mol·K

1. *(a) Takrif*

   (i) haba.

   (ii) kerja.

   (iii) tenaga dalam.

   (iv) Hukum Sifar.

   (v) Hukum Pertama termodinamik.

   (60 markah)

   (b) Terangkan secara ringkas proses berikut:-

   (i) proses adiabatik.

   (ii) proses isobarik.

   (iii) proses isoterma.

   (iv) proses kuasi-statik.

   (40 markah)

2. *Suatu hubungan fungsian antara tiga koordinat yang bebas (x, y, z) dengan f (x, y, z,) = 0. Mengambil x sebagai fungsi y dan z, pembeza tepat dx, dalam sebutan pembezaan separa terhadap y dan z adalah diberikan oleh*

$$\mathrm{d}x = \left(\frac{\partial x}{\partial y}\right)_z \mathrm{d}y + \left(\frac{\partial x}{\partial z}\right)_y \mathrm{d}z\,.$$

   (a) Tuliskan pembeza tepat, dy, dalam sebutan pembezaan separa terhadap x dan z.

   (20 markah)

(b) *Dengan menggunakan jawapan dalam (a) dan ekspresi dx yang diberikan di atas, tunjukkan bahawa*

$$\mathrm{d}x = \left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial x}\right)_z \mathrm{d}x + \left[\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x + \left(\frac{\partial x}{\partial z}\right)_y\right]\mathrm{d}z$$

(20 markah)

(c) *Berdasarkan persamaan yang ditunjukkan di (b), hujahkan bagaimana anda memperolehi hubungan*

$$\left(\frac{\partial x}{\partial y}\right)_z = \frac{1}{\left(\frac{\partial y}{\partial x}\right)_z}$$

(20 markah)

(d) *Berdasarkan persamaan yang ditunjukkan di (b), hujahkan bagaimana anda memperoleh hubungan*

$$\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x + \left(\frac{\partial x}{\partial z}\right)_y = 0$$

(20 markah)

(e) *Berdasarkan persamaan yang ditunjukkan di (a) sehingga (d), tunjukkan bahawa* $\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$

(20 markah)

3. (a) *Takrifkan kapasiti haba C_P pada tekanan tetap.*

(15 markah)

(b) *Takrifkan kapasiti haba C_V pada isipadu tetap.*

(15 markah)

(c) *Bagaimana C_V suatu gas unggul dikaitkan dengan fungsi tenaga dalam, U?*

(15 markah)

(d) *Bagi kapasiti-kapasiti haba gas unggul, C_P dan C_V, yang mana satu nilai numeriknya lebih besar?*

(15 markah)

(e) *Terangkan jawapan anda di (d) secara kualitatif.*

(15 markah)

(f) *Bagi gas ideal, apakah selisih di antara C_P dan C_V, iaitu $C_P - C_V$?*

(15 markah)

(g) *Buktikan bahawa kerja yang dilakukan oleh gas unggul dengan kapasiti haba malar dalam suatu pengembangan adiabatik kuasi-statik sama dengan $W = -C(T_i - T_f)$.*

(10 markah)

4. (a) *Mulai dengan persamaan matematik Hukum Pertama dan persamaan gas unggul, di mana kedua-duanya mengalami proses kuasi-statik secara kecil takterhingga, tunjukkan bahawa*

$$C_p = C_v + nR$$

(30 markah)

(b) *Suatu mol gas mematuhi persamaan keadaan van der Waals*

$$\left(P + \frac{a}{v^2}\right)(v - b) = RT\ ,$$

dan tenaga dalam molarnya diberikan oleh

$$u = cT - \frac{a}{v}\ ,$$

dengan a,b,c dan R adalah pemalar-pemalar.
Hitungkan kapasiti haba molar c_v *dan* c_P *dalam sebutan-sebutan a, b dan c.*

(70 markah)

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