Final Examination
2018/2019 Academic Session

June 2019

JIF314 – Thermodynamics
(Termodinamik)

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat yang bercetak sebelum anda memulakan peperiksaan ini].*

Instructions : Answer **THREE (3)** questions out of **FOUR (4)** questions provided. You may answer **either** in Bahasa Malaysia or in English.

*[**Arahan** : Jawab **TIGA (3)** soalan daripada **EMPAT (4)** soalan yang diberikan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris].*

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

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai].

1. (a). With the help of an illustration, describe a thermodynamic system by defining:

(i). Boundary
(ii). Surrounding
(iii). Isolated
(iv). Open system, and
(v). Closed system

Dengan bantuan satu ilustrasi, terangkan sistem termodinamik dengan mendefinisikan:

(i). Sempadan
(ii). Sekeliling
(iii). Terpencil
(iv). Sistem terbuka, dan
(v). Sistem tertutup

(30 marks/*markah*)

(b). In thermodynamics, we know that going from state 1 to state 2, the work ${}_1W_2$ is done by a force moving through a distance.

If $\delta W = xdx + ydy$, is dW is exact (path-independent integral). Prove the mathematical notation.

Di dalam Termodinamik, kita mengetahui bahawa bermula dari keadaan 1 ke keadaan 2, kerja ${}_1W_2$ *dilakukan oleh satu daya yang bergerak melalui suatu jarak. Jika* $\delta W = xdx + ydy$*, is* dW *adalah betul (kamiran laluan tak bersandar). Buktikan notasi matematik tersebut.*

(30 marks/*markah*)

(c). Describe the enthalpy of a homogeneous thermodynamic system.
Terangkan entalpi sistem termodinamik homogen.

(10 marks/*markah*)

(d). Determine the specific volume of refrigerant-134a at 1 MPa and 50 °C, using the
Tentukan isipadu tertentu bahan penyejuk-134a pada 1 MPa dan 50 °C, menggunakan

(i). ideal-gas equation of state.
keadaan persamaan gas unggul.

(ii). generalized compressibility chart.
carta kebolehmampatan umum.

Compare the values obtained to the actual value of 0.021796 m^3 kg^{-1} and determine the error involved in each case.
Bandingkan nilai yang diperolehi dengan nilai sebenar 0.021796 m^3 kg^{-1} dan tentukan kesilapan yang terlibat dalam setiap kes.

Thermodynamic parameters for refrigerant-134a are given as follow;
Parameter termodinamik bagi bahan penyejuk-134a diberikan sebagai berikut;

$R = 0.0815$ kPa m^3 kg^{-1} K^{-1}
$P_{cr} = 4.059$ MPa
$T_{cr} = 374.2$ K

(30 marks/*markah*)

2. (a). On a hot day, a student turns his fan ON when he leaves his room in the morning as shown in Figure 1. When he returns in the evening, will the room be warmer or cooler than the neighbouring rooms? Why? Assume all doors and windows are kept closed. Relate the answers to the law of thermodynamics.

Pada hari yang panas, seorang pelajar 'ON' kipasnya apabila dia meninggalkan biliknya pada waktu pagi seperti pada Rajah 1. Apabila dia pulang pada waktu petang, adakah bilik itu lebih hangat atau lebih sejuk daripada bilik-bilik yang berdekatan? Mengapa? Anggapkan semua pintu dan tingkap tertutup rapat. Kaitkan jawapan dengan hukum-hukum termodinamik.

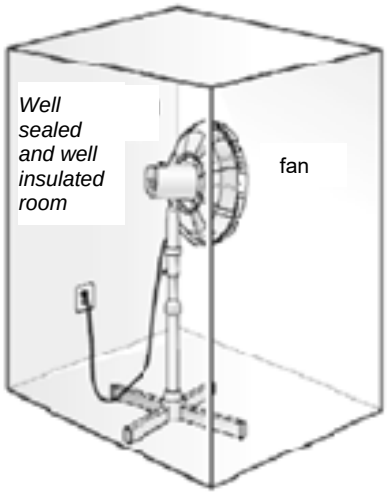


Figure 1

Rajah 1

(30 marks/*markah*)

(b). Determine the pressure of water vapour at 350 °C and 0.035262 $m^3\ kg^{-1}$, using the
Tentukan tekanan wap air pada 350 °C dan 0.035262 $m^3\ kg^{-1}$, menggunakan

(i). ideal-gas equation of state.
keadaan persamaan gas unggul.

(ii). generalized compressibility chart.
carta kebolehmampatan umum.

Thermodynamic parameters for water vapour are given as follow;
Parameter termodinamik untuk wap air diberikan sebagai berikut;

$R = 0.4615\ kPa\ m^3\ kg^{-1}\ K^{-1}$
$P_{cr} = 22.06\ MPa$
$T_{cr} = 647.1\ K$
$v = 0.035262\ m^3\ kg^{-1}$
$T = 350°C$
$P = 7.0\ MPa$

(40 marks/*markah*)

(c). A rigid tank contains 10 kg of water at 90 °C. If 8 kg of the water is in the liquid form and the rest is in the vapour form, determine the volume of

Tangki tegar mengandungi 10 kg air pada 90 °C. Sekiranya 8 kg air dalam bentuk cecair dan selebihnya dalam bentuk wap, tentukan isipadu

(i). the tank,
tangki,

(ii). saturated liquid,
cecair tepu,

(iii). saturated vapour,
wap tepu

Thermodynamic parameters for saturated water are given as follow;
Parameter termodinamik untuk air tepu diberikan seperti berikut;

P_{sat} at $_{90°C}$ = 70.183 kPa
V_f = 0.001036 m^3 kg^{-1}
V_g = 2.3593 m^3 kg^{-1}

(30 marks/*markah*)

3. (a). A flat wall is composed of 20 cm of brick having a thermal conductivity k_t = 0.72 W/m K. The right face temperature of the brick is 900 °C, and the left face temperature of the brick is 20 °C as shown in Figure 2. Determine the rate of heat conduction through the wall per unit area of the wall.

Suatu dinding rata terdiri daripada 20 cm bata yang mempunyai kekonduksian terma k_t = 0.72 W/m K. Suhu muka kanan bata ialah 900 °C, dan suhu muka kiri bata ialah 20 °C seperti pada Rajah 2. Tentukan kadar pengaliran haba melalui dinding per unit kawasan dinding.

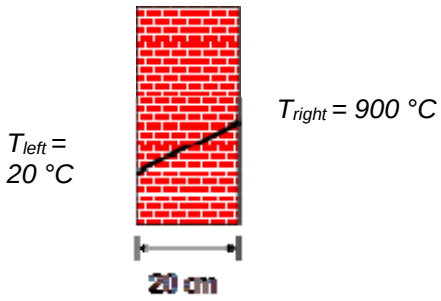


Figure 2

Rajah 2

(30 marks/*markah*)

(b). Describe the Second Law of Thermodynamics based on Kelvin-Planck statement.

Terangkan Hukum Kedua Termodinamik berdasarkan penerangan Kelvin-Plank.

(10 marks/*markah*)

(c). A piston-cylinder device initially contains 0.4 m^3 of air at 100 kPa and 80 °C as shown in Figure 3. The air is now compressed to 0.1 m^3 in such a way that the temperature inside the cylinder remains constant. Determine the work done during this process.

Alat piston silinder pada mulanya mengandungi 0.4 m^3 udara pada 100 kPa dan 80 °C seperti pada Rajah 3. Udara kini dimampatkan kepada 0.1 m^3 sedemikian rupa sehingga suhu di dalam silinder kekal malar. Tentukan kerja yang dilakukan semasa proses ini.

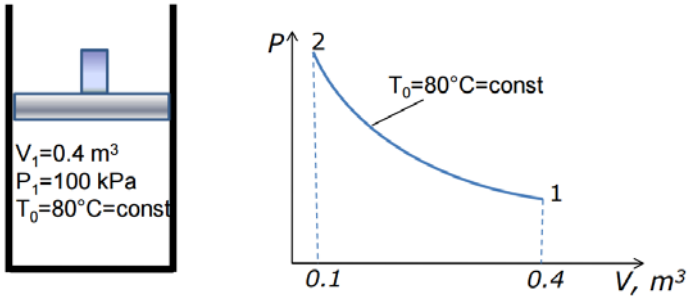


Figure 3

Rajah 3

(30 marks/*markah*)

(d). A rigid tank contains air at 500 kPa and 150 °C. As a result of heat transfer to the surroundings, the temperature and pressure inside the tank drop to 65°C and 400kPa, respectively as shown in Figure 4. Determine and discuss the boundary work done during this process.

Tangki tegar mengandungi udara pada 500 kPa dan 150 °C. Akibat pemindahan haba ke persekitaran, suhu dan tekanan di dalam tangki masing-masing turun ke 65 °C dan 400 kPa seperti pada Rajah 4. Tentukan dan bincangkan kerja sempadan yang dilakukan semasa proses ini.

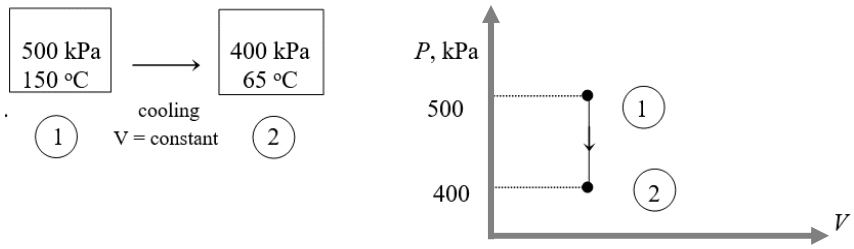


Figure 4

Rajah 4

(30 marks/*markah*)

4. (a). Define the First Law of Thermodynamics as an expression of the conservation of energy principle which relates to the sum of three separate energies.

Definisikan Hukum Pertama Termodinamik sebagai satu ungkapan terhadap prinsip keabadian tenaga yang berkaitan dengan jumlah tiga tenaga berasingan.

(30 marks/*markah*)

(b). A steam power plant operates on a thermodynamic cycle in which water circulates through a boiler, turbine, condenser, pump, and back to the boiler. For each kilogram of steam (water) flowing through the cycle, the cycle receives 2000 kJ of heat in the boiler, rejects 1500 kJ of heat to the environment in the condenser, and receives 5 kJ of work in the cycle pump. Determine the work done by the steam in the turbine, in kJ / kg. Given:

Loji kuasa stim beroperasi pada kitaran termodinamik di mana air beredar melalui dandang, turbin, kondenser, pam, dan kembali ke dandang. Bagi setiap kilogram stim (air) yang mengalir melalui kitaran, kitaran menerima 2000 kJ haba dalam dandang, menolak 1500 kJ haba ke persekitaran dalam kondenser, dan menerima 5 kJ kerja dalam pam kitaran. Tentukan kerja yang dilakukan oleh stim di turbin, dalam kJ / kg. Diberi:

$$Q_{net} - W_{net} = \Delta E_{cycle} \quad , \quad w = \frac{W}{m} \quad \text{and} \quad q = \frac{Q}{m}$$

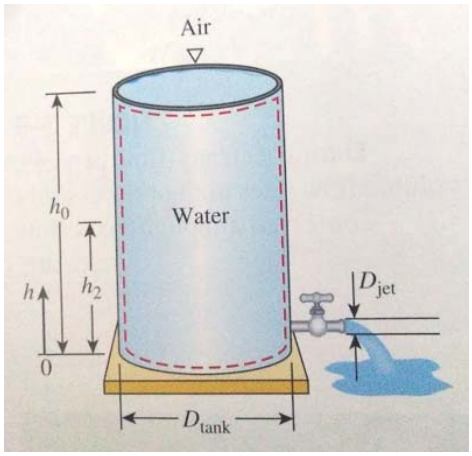
(30 marks/*markah*)

(c). A 1.2 m high 0.9 m diameter cylindrical water tank top is open to the atmosphere is initially filled with water. Now the discharge plug near the bottom of the tank is pulled out, and water jet whose diameter is 1.27 cm streams out as shown in Figure 5. The mean velocity of the jet is given by $v = \sqrt{2gh}$, where h is the height in the tank measured from the centre of the hole and g is the gravitational acceleration. Determine how long it will take for the water level in the tank to drop to 0.6 m level from the bottom.

Atas tangki air silinder 1.2 m tinggi berdiameter 0.9 m terbuka ke atmosfera pada awalnya diisi dengan air. Sekarang plag pelepasan berhampiran bahagian bawah tangki ditarik keluar, dan air mengalir keluar melalui jet air dengan diameter 1.27 cm seperti pada Rajah 5. Halaju rata jet diberikan oleh $v = \sqrt{2gh}$*, di mana h ialah ketinggian dalam tangki yang diukur dari pusat lubang dan g ialah pecutan graviti. Tentukan berapa lama ia akan mengambil untuk paras air dalam tangki untuk jatuh ke tahap 0.6 m dari bawah.*

Given;

Diberikan;



$$dt = -\frac{D_{tank}^2}{D_{jet}^2}\frac{dh}{\sqrt{2gh}}$$

Figure 5
Rajah 5

(40 marks/*markah*)

…12/-

Appendix A:

1 atm = 101.325 kPa
1 Pa = 1 $N.m^{-2}$

PV = nRT

$$Q = \int_{t2}^{t1} \dot{Q} dt$$

$$\dot{Q}_{cond} = -k_t A \frac{\Delta T}{\Delta x}$$

$$\dot{Q}_{conv} = hA(T_s - T_f)$$

$$\dot{Q}_{rad} = \varepsilon \sigma A(T_s^4 - T_{surr}^4)$$

$$\dot{m} = \rho \dot{V}$$

$$x = \frac{m_{vapor}}{m_{total}}$$

$$x = \frac{V_{avg} - V_f}{V_{fg}}$$

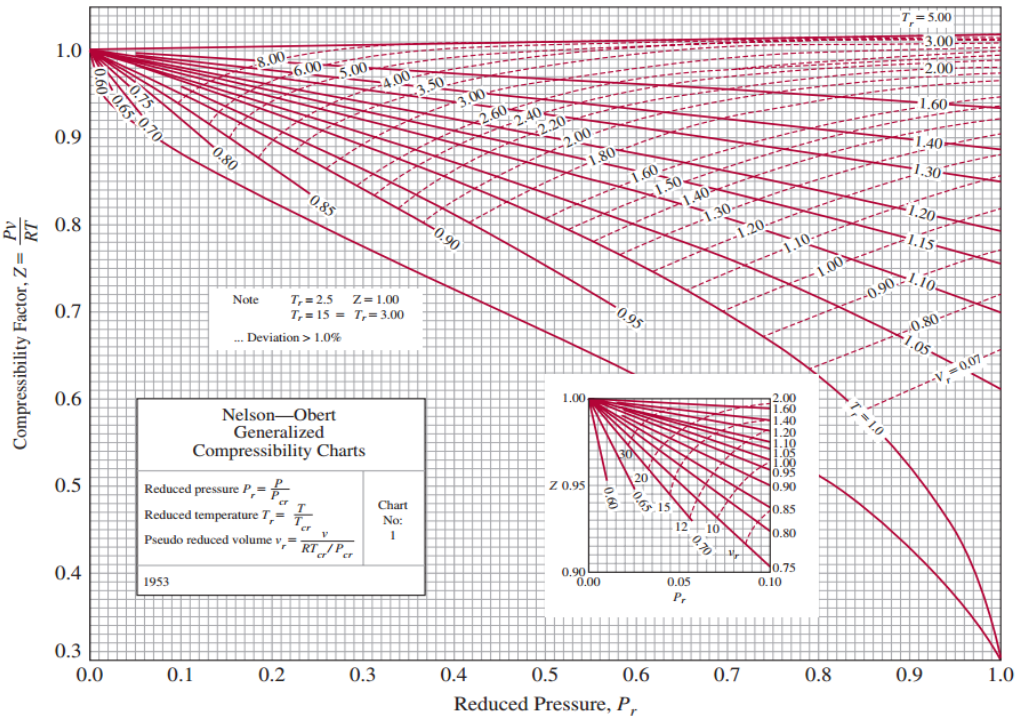
$$V = V_f + V_{fg}$$

$$\dot{m}_{in} - \dot{m}_{out} = \frac{dm_{CV}}{dt}$$

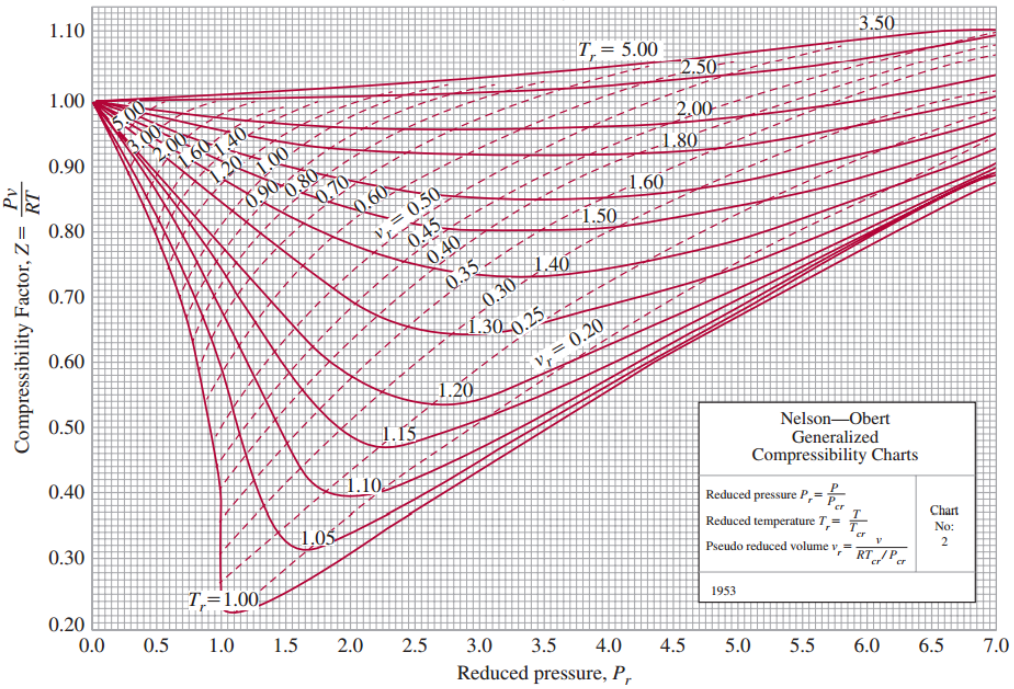
…13/-

Appendix B: Nelson-Obert generalized compressibility chart

(a) $0 < P_r < 1.0$



(b) $0 < P_r < 7$



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