UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

KIT 252 – Unit Operations
[Operasi Unit]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of ELEVEN pages of printed material before you begin the examination

Instructions:

Answer FIVE (5) questions.

Answer each question on a new page.

You may answer either in Bahasa Malaysia or in English.

If a candidate answers more than five questions, only the answers to the first five questions in the answer sheet will be graded.

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

Appendix: Factors For Unit Conversions.

1. (a) Explain the following terms:

(i) Latent Heat

(ii) Standard Heat of Reaction

(iii) Heat of Reaction

(5 marks)

(b) In an industry, formaldehyde (HCHO) can be produced via catalytic oxidation of methanol (CH_3OH). Steam is produced as a by-product. The reactants enter the reactor at 100 ºC. Assuming that the reaction is complete and that the products leave at 250 ºC, calculate:

(i) The standard heat of reaction, ΔH°_{298}

(ii) The heat removed or added to the reactor.

(Standard heat of formation, kJ/g mol: CH_3OH = -201.25; HCHO = -115.89; H_2O = -241.826
Heat Capacity, J / g mol·K : CH_3OH = 49.68; O_2 = 30.412; HCHO = 42.576; H_2O = 35.106)

(15 marks)

2. (a) A soft drink manufacturer uses 3 volumes of carbon dioxide gas and 1 volume of water to produce a soda drink at 0 °C and atmospheric pressure. If 1 m^3 of water is 1000 kg, calculate the:

(i) mass fraction and

(ii) the mol fraction of the carbon dioxide gas in the drink.

(10 marks)

(b) 100 g moles of CO at 300 °C is burned with 100 g moles of O_2 which is at 100 °C. The exit gasses leave at 400 °C. What is the heat transfer to or from the system in kJ?

(Standard heat of formation, kJ/g mol: CO = -110.523; CO_2 = -393.513
Heat Capacity, J / g mol·K : CO, 300 °C = 31.193; O_2, 100 °C = 30.412; O_2, 400 °C = 32.065; CO_2, 400 °C = 46.673)

(10 marks)

3. (a) State the Bernoulli principle and derive its equation.

(7 marks)

(b) Water flows at a rate of 12 L min^{-1} through a horizontal pipe having a 2 cm internal diameter. A venturi tube having a throat diameter of 1 cm is installed in the pipe. Calculate:

(i) The water velocity in the pipe and in the venturi throat

(ii) The absolute pressure, if the water has a gauge pressure of 80 kPa in the pipe.

(iii) The gauge pressure in the venturi throat.

(13 marks)

4. (a) Explain Pascals Principle using a suitable example.

(6 marks)

(b) A long tube with an internal radius of 2 cm and a length of 40 cm was fixed into the top of a wine cask. The cask was 20 cm high with a radius of 20 cm. Water was slowly added to the vertical tube. Calculate:

(i) The weight of water in the flask.

(ii) The gauge pressure of water at the bottom of the flask.

(iii) The force exerted on the base of the flask due to the gauge pressure.

(14 marks)

5. In a power station, coal containing 79 wt % of carbon, 5 wt % of unoxidized hydrogen and 16 wt % of solid inert is burned in air. As much as 30 % of excess air was fed into the system. Both the carbon and hydrogen were completely oxidized to CO_2 and H_2O respectively.

(a) Draw the flowchart of the process and state the reactions involved.

(6 marks)

(b) Calculate the amount of air added to the process per kg of coal.

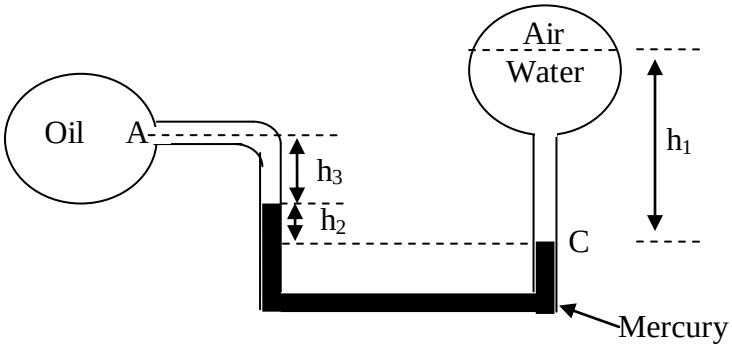
(6 marks)

(c) Assuming complete combustion, calculate the composition of the stack gas leaving the furnace.

(8 marks)

6. (a) A manometer U tube is attached to two vessels as shown in the figure below. If the pressure of air in the second vessel is 100 kN m^{-2}

(i) What is the absolute pressure at A?

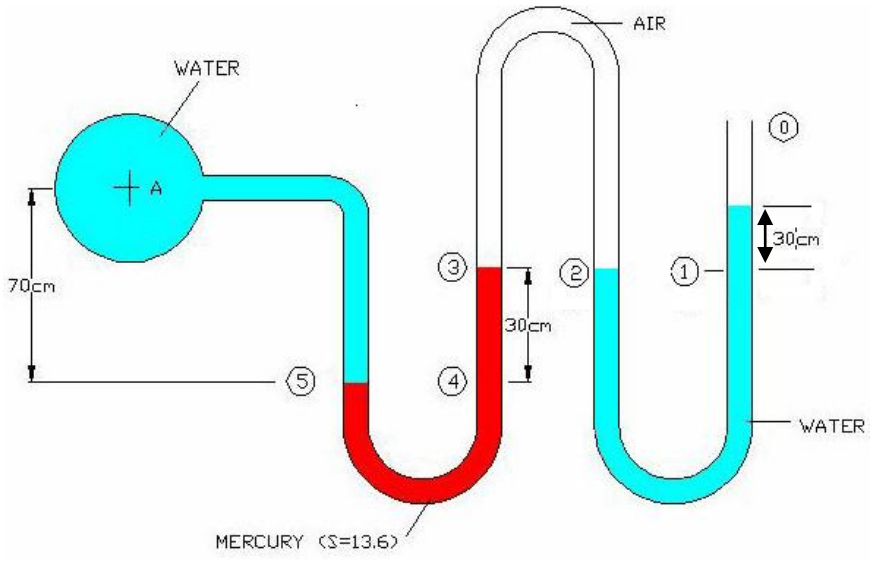


h_1 = 0.3 m; h_2 = 0.1 m; h_3 = 0.2 m; $S.G_{oil}$ = 0.8; $S.G_{Hg}$ = 13.6; ρ_{water} = 1000 kgm^{-3}

(ii) If oil in the left hand limb is replaced by air, what is the pressure at A in order to maintain the same configuration as in the image?

(10 marks)

(b) Obtain the pressure at A.



(10 marks)

7. The wall in a furnace consists of 125 mm thick refractory bricks and 125 mm thick insulating firebricks separated by an air gap. A 12 mm thick plaster covers the outer wall. The inner surface of the wall is at 1100 ºC and the ambient temperature is 25 ºC. The heat transfer coefficient on the outside wall to the air is 17 Wm^{-2} K^{-1}, and the resistance to heat flow of the air gap is 0.16 KW^{-1}. The thermal conductivities of refractory brick, insulating firebrick and plaster are 1.6, 0.3 and 0.14 $Wm^{-1}K^{-1}$, respectively. Calculate:

(a) The rate of heat loss per unit area of wall surface,

(8 marks)

(b) The interface temperatures throughout the wall and

(8 marks)

(c) The temperature at the outside surface of the wall.

(4 marks)

TERJEMAHAN

Arahan:

Jawab LIMA (5) soalan sahaja.

Jawab setiap soalan pada muka surat yang baru.

Anda dibenarkan menjawab soalan ini sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.

Jika calon menjawab lebih daripada lima soalan, hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

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

1. (a) Terangkan maksud istilah-istilah berikut:

(i) Haba pendam.

(ii) Haba tindakbalas piawai.

(iii) Haba tindak balas.

(5 markah)

(b) Dalam industri, formaldehid (HCHO) boleh dihasilkan melalui proses pemangkinan pengoksidaan methanol (CH_3OH). Proses ini menghasilkan stim sebagai bahan sampingan. Bahan tindak balas memasuki reaktor pada suhu 100 °C. Dengan anggapan bahawa tindak balas ini adalah lengkap dan hasil tindak balas dibebaskan pada suhu 250 °C, Kirakan:

(i) Haba tindakbalas piawai , ΔH°_{298}

(ii) Haba yang dikeluarkan atau ditambahkan ke dalam reaktor.

(Pembentukan haba piawai, kJ/g mol: CH_3OH = -201.25; HCHO = -115.89; H_2O = -241.826
Muatan haba, $J / g\,mol \cdot K$:CH_3OH = 49.68; O_2 = 30.412; HCHO = 42.576; H_2O = 35.106)

(15 markah)

2. (a) Pengilang minuman ringan menggunakan 3 bahagian isipadu gas karbon dioksida dan 1 bahagian isipadu air untuk menghasilkan air minuman soda pada suhu 0 °C dan tekanan atmosfera. Apabila 1 m^3 air bersamaan dengan 1000 kg, kirakan:

(i) Pecahan jisim dan

(ii) Pecahan mol gas karbon dioksida di dalam minuman tersebut.

(10 markah)

(b) 100 gram mol CO dibakar pada 300 °C dengan 100 gram mol O_2 pada 100 °C. Gas yang terhasil dibebaskan pada 400 °C. Apakah haba yang dibebaskan kepada atau daripada sistem ini dalam kJ?

(Pembentukan haba piawai, kJ/g mol: CO = -110.523; CO_2 = -393.513
Muatan haba, $J / g\,mol \cdot K$: CO, 300 °C = 31.193; O_2, 100 °C = 30.412; O_2, 400 °C = 32.065; CO_2, 400 °C = 46.673)

(10 markah)

3. (a) Nyatakan prinsip Bernoulli dan terbitkan persamaan Bernoulli

(7 markah)

(b) Air mengalir pada kadar 12 L min^{-1} melalui paip mendatar yang dalamnya berdiameter 2 cm. Tiub venturi yang mempunyai kerongkong berdiameter 1 cm dipasangkan di dalam paip ini. Kirakan:

(i) Kelajuan air di dalam paip dan di dalam kerongkong venturi.

(ii) Tekanan mutlaknya sekiranya air mempunyai tekanan gaj 80 kPa di dalam paip.

(iii) Tekanan gaj di dalam kerongkongan venturi.

(13 markah)

4. (a) Terangkan Prinsip Pascal dengan memberikan contoh yang sesuai.

(6 markah)

(b) Sebuah tiub sepanjang 40 cm dan berdiameter dalam 2 cm ditetapkan kedudukannya pada bahagian atas tong penyimpanan minuman keras. Tong penyimpanan ini setinggi 20 cm dan berdiameter 20 cm. Air dimasukkan secara perlahan-lahan pada tiub tegak ini. Kirakan:

(i) Berat air di dalam bekas ini.

(ii) Tekanan gaj air pada bahagian bawah bekas.

(iii) Daya yang dikenakan pada bahagian dasar bekas disebabkan oleh tekanan gaj.

(14 markah)

5. Di sebuah stesen janakuasa, batu bara yang mengandungi 79 wt % karbon, 5 wt % hidrogen tidak teroksida dan 16 wt % pepejal tidak reaktif terbakar dalam udara. Sebanyak 30% lebihan udara dibekalkan kepada sistem. Kedua-dua karbon dan hidrogen masing-masing teroksida lengkap kepada CO_2 dan H_2O.

(a) Lukiskan gambarajah proses dan nyatakan tindak balas yang berlaku.

(6 markah)

(b) Kirakan jumlah udara yang ditambah kepada proses per kg batu bara.

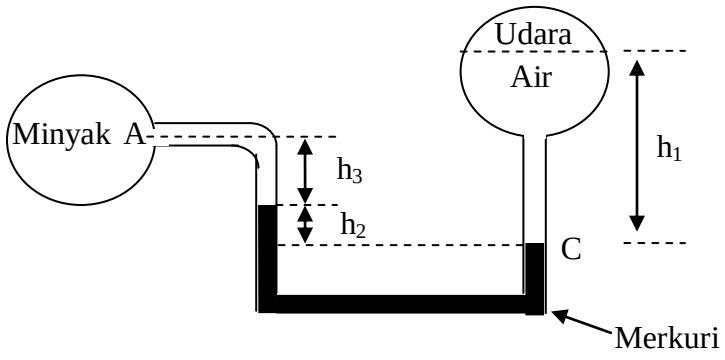
(6 markah)

(c) Dengan menanggap pembakaran lengkap berlaku, kirakan komposisi gas yang dikeluarkan daripada relau.

(8 markah)

6. (a) Sebuah manometer tuib U disambung kepada dua bejana seperti di dalam rajah di bawah. Sekiranya tekanan udara di dalam bejana kedua ialah 100 kNm^{-2};

(i) Apakah tekanan mutlak di A?

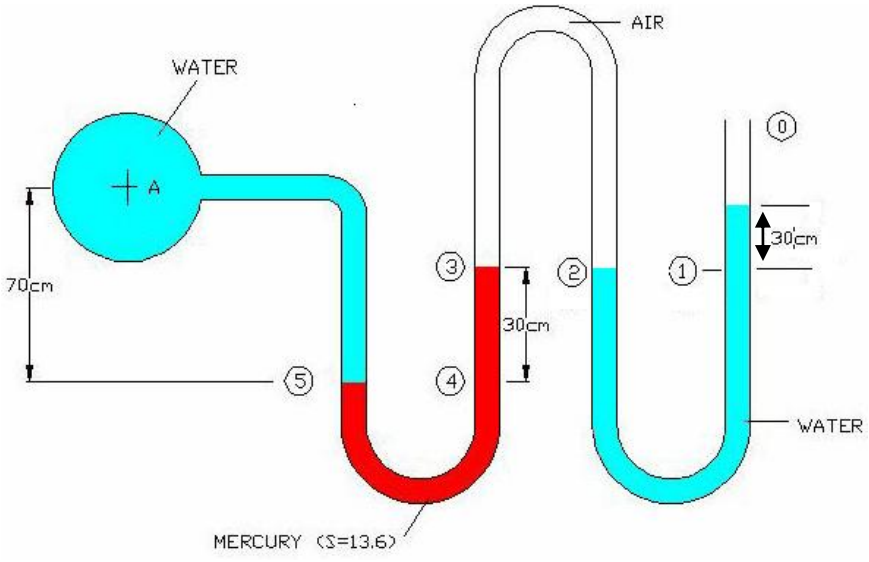


$h_1 = 0.3$ m; $h_2 = 0.1$ m; $h_3 = 0.2$ m; $S.G_{minyak} = 0.8$; $S.G_{Hg} = 13.6$; $\rho_{air} = 1000\ kgm^{-3}$

(ii) Sekiranya minyak didalam lengan kiri diganti dengan udara, apakah tekanan di A untuk mengekalkan konfigurasi yang sama seperti didalam rajah?

(10 markah)

(b) Dapatkan tekanan di A.



(10 markah)

7. Dinding pada ketuhar terdiri daripada batu bata tahan panas berketebalan 125 mm dan batu bata penebat berketebalan 125 mm, yang dipisahkan oleh udara. Plaster setebal 12 mm menutupi permukaan luar dinding. Permukaan dalam dinding mempunyai suhu 1100 °C dan suhu ambien ialah 25 °C. Pemalar haba pemindahan pada dinding luar ke udara ialah 17 Wm^{-2} K^{-1}, dan rintangan terhadap aliran haba bagi udara ialah 0.16 KW^{-1}. Konduksi thermal bagi batu bata tahan panas, batu bata penebat dan plaster adalah masing-masing 1.6, 0.3 and 0.14 $Wm^{-1}\cdot K^{-1}$. Kiralah:

(a) Kadar kehilangan haba per unit luas permukaan dinding,

(8 markah)

(b) Suhu perantara pada keseluruhan dinding dan

(8 markah)

(c) Suhu pada permukaan luar dinding.

(4 markah)

APPENDIX

FACTORS FOR UNIT CONVERSIONS

Quantity	Equivalent Values
Mass	1 kg = 1000g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz 1 lb_m = 16 oz = $5x10^{-4}$ ton = 453.593 g = 0.453593 kg
Length	1m = 100 cm = 1000 mm = 10^6 microns (μm) = 10^{10} angstroms (Å) = 39.37 in. = 3.2808 ft = 1.0936 yd = 0.0006214 mile 1ft = 12 in. = 1/3 yd = 0.3048 m = 30.48 cm
Volume	1 m^3 = 1000 L = 10^6 cm^3 = 10^6 mL = 35.3145 ft^3 = 220.83 imperial gallons = 264.17 gal = 1056.68 qt 1 ft^3 = 1728 $in.^3$ = 7.4805 gal = 0.028317 m^3 = 28317 L = 28, 317 cm^3
Force	1N = 1 kg·m/s^2 = 10^5 dynes = 10^5 g·cm/s^2 = 0.22481 lb_f 1 lb_f = 32.174 lb_m.ft/s^2 = 4.4482 N = 4.4482 x 10^5 dynes
Pressure	1 atm = 1.01325 x 10^5 N/m^2 (Pa) = 101.325 kPa = 1.01325 bar = 1.01325 x 10^6 dynes/cm^2 = 760 mm Hg at 0°C (torr) = 10.333 m H_2O at 4°C = 14.696 $lb_f/in.^2$ (psi) = 33.9 ft H_2O at 4°C = 29.921 in. Hg at O°C
Energy	1 J = 1 N·m = 10^7 ergs = 10^7 dyne·cm = 2.778 x 10^{-7} kW·h = 0.23901 cal = 0.7376 ft-lb_f = 9.486 x 10^{-4} Btu
Power	1 W = 1 J/s = 0.23901 cal/s = 0.7376 ft·lb_f/s = 9.486 x 10^{-4} Btu/s = 1.341 x 10^{-3} hp

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