UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2009/2010 Academic Session

April/May 2010

KIT 252 – Unit Operations
[Operasi Unit]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of NINE 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 concentration, C (mol L^{-1}), varies with time t (min), according to the following equation:

$$C = 3.00 \exp(-2.00t)$$

(i) What are the units of 3.00 and 2.00?

(ii) Suppose the concentration is measured at $t = 0$ and $t = 1$ min. Use two-point linear interpolation or extrapolation to estimate C ($t = 0.6$ min) and t ($C = 0.10$ mol L^{-1} from the measured values, and compare these results with the true values of these quantities.

(iii) Sketch a curve of C versus t, and show graphically the points you determined in part (ii).

(20 marks)

2. One thousand kilograms per hour of a mixture containing equal parts by mass of methanol and water is distilled. Product streams leave the top and the bottom of the distillation column. The flow rate of the bottom stream is measured and found to be 673 kg h^{-1}, and the overhead stream is analyzed and found to contain 96.0 wt % methanol.

(i) Calculate the mass and mole fractions of methanol and the molar flow rates of methanol and water in the bottom product stream.

(ii) Suppose the bottom product stream is analyzed and the mole fraction of methanol is found to be significantly higher than the value calculated in part (i). List as many possible reasons for discrepancy.

(20 marks)

3. Air is heated from 25 °C to 150 °C prior to entering a combustion furnace. The change in specific enthalpy associated with this transition is 3,640 J mol^{-1}. The flow rate of air at the heater outlet is 1.25 m^3 min^{-1} and the air pressure at this point is 122 kPa absolute. *Given : volume of any gas at STP is 22.4 L.*

(i) Calculate the heat requirement in kW, assuming ideal gas behavior and that kineti, ΔE_k and potential energy, ΔE_p changes from the heater inlet to the outlet are negligible.

(ii) Would the value of ΔE_k [which was neglected in part (i)] be positive or negative, or would you need more information to be able to tell? If the latter, what additional information would be needed?

(20 marks)

4. A desktop computer is to be cooled by a fan whose flow rate is 0.34 m^3 min^{-1}

   (i) Determine the mass flow rate of air through the fan at an elevation of 3,400 m where the air density is 0.7 kg m^{-3}.

   (ii) If the average velocity of air is not to exceed 110 m min^{-1}, determine the diameter of the casing of the fan.

   (iii) As an engineer, please make a general comment about this problem.

   (20 marks)

5. An oil storage tank has 20-mm steel walls covered with 50 mm of fiberglass insulation. If the oil temperature is kept at 150 °C:

   (i) What is the rate of heat loss when the outside temperature is 20°C and the external air coefficient is 20 W m^{-2} $°C^{-1}$?

   (ii) How much would the heat loss be reduced by doubling the thickness of the insulation?
   Given that the thermal conductivity value for fiberglass is 0.0467 W m^{-1} $°C^{-1}$.

   (20 marks)

6. Ammonia is burned to form nitric oxide in the following reaction:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

   (i) Calculate the ratio of lb mole O_2 react/lb mole NO formed

   (ii) If ammonia is fed to a continuous reactor at a rate of 100.0 kmol NH_3 h^{-1}, what oxygen feed rate (kmol h^{-1}) would correspond to 40.0 % excess O_2?

   (iii) If 50.0 kg of ammonia and 100.0 kg of oxygen are fed to a batch reactor, determine the limiting reactant, the percentage by which the other reactant is in excess, the extent of reaction (mol) and mass of NO produced (kg) if the reaction proceeds to completion.

   (20 marks)

7. The air velocity in the duct of a heating system is to be measured by a Pitot-static probe inserted into the duct parallel to flow. If the differential height between the water columns connected to the two outlets of the probe is 2.4 cm, determine:

   (i) The flow velocity.

   (ii) The pressure rise at the tip of the probe. The air temperature and pressure in the duct are 45 °C and 98 kPa, respectively.

(20 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. Kepekatan, C (mol L^{-1}), berubah dengan masa t (min), mengikut persamaan di bawah

$$C = 3.00 \exp(-2.00t)$$

(i) Apakah unit bagi 3.00 dan 2.00?

(ii) Andaikan kepekatan diukur pada $t = 0$ dan $t = 1$ min. Gunakan 2 titik linear interpolasi dan extrapolasi untuk menganggarkan C ($t = 0.6$ min) dan t ($C = 0.10$ mol L^{-1}) daripada nilai yang diukur, dan bandingkan keputusan ini dengan nilai sebenar kuantiti tersebut.

(iii) Lakarkan lengkung C melawan t, dan tunjukkan secara grafik titik yang ditentukan di bahagian (ii).

(20 markah)

2. Seribu kilogram per jam campuran mengandungi bahagian yang sama mengikut jisim metanol dan air yang disulingkan. Aliran hasil meninggalkan bahagian atas dan bawah turus penyulingan. Kadar aliran pada bahagian bawah aliran disukat dan nilainya ialah 673 kg j^{-1}, dan aliran di bahagian atas dianalisa dan didapati mengandungi 96.0 wt % metanol.

(i) Kiralah jisim dan pecahan mol bagi metanol dan kadar aliran molar methanol dan air bagi aliran hasil di bahagian bawah.

(ii) Andaikan hasil aliran di bawah dianalisa dan pecahan mol metanol didapati sangat tinggi daripada nilai yang dikira di bahagian (i). Senaraikan seberapa banyak alasan yang mungkin untuk menerangkan perbezaan ini.

(20 markah)

3. Udara dipanaskan dari 25 °C hingga 150 °C sebelum memasuki sebuah kebuk pembakaran. Perubahan entalpi tentu yang berkaitan dengan peralihan ini ialah 3,640 J mol^{-1}. Kadar aliran udara pada saluran keluar pemanas ialah 1.25 m^3 min^{-1} dan tekanan mutlak udara pada titik ini ialah 122 kPa. *Diberi isipadu bagi mana-mana gas pada keadaan STP ialah 22.4 L.*

(i) Kiralah nilai haba yang diperlukan dalam kW, dengan mengandaikan sifat gas unggul dan perubahan tenaga kinetik ΔE_k dan keupayaan, ΔE_p dari saluran masuk pemanas kepada saluran keluar boleh diabaikan.

(ii) Adakah nilai ΔE_k [yang diabaikan di bahagian (i)] positif atau negatif, atau adakah anda memerlukan lebih banyak maklumat untuk menjawabnya? Jika ya, apakah maklumat tambahan yang diperlukan?

(20 markah)

4. Sebuah komputer disejukkan oleh kipas dengan kadar aliran 0.34 m^3 min^{-1}.

   (i) Tentukan kadar aliran jisim bagi udara melalui kipas pada ketinggian 3,400 m dengan ketumpatan udara ialah 0.7 kg m^{-3}.

   (ii) Juga, sekiranya purata had laju udara tidak melebihi 110 m min^{-1}, tentukan diameter penutup kipas tersebut.

   (iii) Sebagai seorang jurutera, sila buat sebarang ulasan umum bagi permasalahan di atas.

   (20 markah)

5. Tangki simpanan minyak mempunyai 20-mm keluli yang diselaputi dengan 50 mm penebat gentian kaca. Jika suhu minyak yang disimpan ialah 150 °C:

   (i) Apakah kadar kehilangan haba apabila suhu luar ialah 20 °C dan pekali udara luaran ialah 20 W m^{-2} $°C^{-1}$?

   (ii) Berapa banyakkah kehilangan haba dikurangkan dengan menggandakan ketebalan penebat?

   Diberi nilai kekonduksian haba bagi gentian kaca ialah 0.0467 W m^{-1} $°C^{-1}$.

   (20 markah)

6. Amonia dibakar untuk menghasilkan nitrik oksida melalui tindak balas di bawah:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

   (i) Kiralah nisbah bagi lb mol O_2 bertindak/lb-mol NO terbentuk.

   (ii) Jika amonia dimasukkan ke dalam reaktor berterusan pada kadar 100.0 kmol NH_3 j^{-1}, maka berapakah kadar kemasukan oksigen (kmol j^{-1}) yang bersesuaian dengan 40.0 % O_2 berlebihan?

   (iii) Jika 50.0 kg amonia dan 100.0 kg oksigen dimasukkan ke dalam reactor tunggal, tentukan bahan penghad, peratusan berlebihan bagi bahan tindak balas yang satu lagi, perluasan tindak balas (mol) dan jisim NO yang terbentuk (kg) jika tindak balas berlaku dengan lengkap.

   (20 markah)

7. Had laju udara di dalam sistem saluran pemanasan diukur dengan menggunakan alat prob *Pitot-static* yang dimasukkan ke dalam saluran selari dengan pengalirannya. Jika perbezaan ketinggian antara kolum air yang bersambung dengan dua prob saluran keluar ialah 2.4 cm, tentukan,

   (i) Halaju aliran,

   (ii) Peningkatan tekanan pada hujung prob tersebut.

   Suhu udara dan tekanan dalam saluran itu masing-masing 45 °C dan 98 kPa.

(20 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