
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

EKC 377 – Renewable and Alternative Energies
[Tenaga-Tenaga Alternatif dan Boleh Diperbaharu]

Duration : 3 hours
[Masa : 3 jam]

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

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instruction: Answer **ALL** questions.

Arahan: Jawab **SEMUA** soalan.]

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

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

Answer ALL questions.

Jawab SEMUA soalan.

1. The article below was taken from “The Star”, a local daily newspaper dated 21st February 2012. Read the article and answer the following questions:

Artikel di bawah telah diambil daripada “The Star”, akhbar harian tempatan bertarikh 21 Februari 2012. Baca keratan surat khabar tersebut dan jawab soalan-soalan berikut:

The Star – Tuesday February 21, 2012

Biodiesel use nationwide in two years

TANJUNG KARANG: There is a target for bio-diesel use to go nationwide by 2014, said Plantation Industries and Commodities Minister Tan Sri Bernard Dompok. The implementation could not be made sooner because there were not enough blending facilities for the alternative fuel. “The in-line blending system for biodiesel currently involves six petroleum depots in the country,” Dompok told reporters after launching the B5 biodiesel programme for the central region at Jeti Bagan Pasir yesterday.

B5 is a blend of 95% regular petroleum-based diesel and 5% palm methylester, which can be used in normal diesel engine vehicles without modification. Dompok also said his ministry was studying ways to reduce the amount of regular diesel in biodiesel by increasing the use of palm methylester. “We can increase the use of palm methylester in biodiesel by 10%, 30% or 50% in the future after conducting research,” he said.

He also said that the Government had no intention on increasing the price of B5. B5 is sold at the same price as regular diesel — RM1.80 per litre. The B5 programme, first introduced in 2006, is being implemented in phases in the central region of Peninsular Malaysia since June 2011. The central region covers Putrajaya, Malacca, Negri Sembilan, Kuala Lumpur and Selangor.

On the nation’s involvement in the use of B5, Dompok said it had put Malaysia on par with countries such as Thailand, Indonesia and South Korea.

- [a] Define biodiesel and briefly describe how can biodiesel be produced.
Takrifkan ‘biodiesel’ dan terangkan secara ringkas bagaimana biodiesel dihasilkan.
[5 marks/markah]
- [b] Briefly discuss three (3) advantages of using biodiesel.
Bincangkan secara ringkas tiga (3) kelebihan penggunaan biodiesel.
[5 marks/markah]
- [c] Based on the article, the B5 programme was first introduced in 2006, but the implementation started only in 2011. What do you think is the cause of this delay and how can it be overcome for future biofuel programmes?
Berdasarkan artikel, program B5 telah diperkenalkan pada 2006, tetapi implementasi hanya bermula pada 2011. Pada pendapat anda, apakah yang menyebabkan kelewatan ini dan bagaimanakah ia boleh diatasi bagi program tenaga bio yang lain pada masa hadapan.
[5 marks/markah]

- [d] Apart from B5, discuss the advantages and disadvantages of one more type of biofuel for the transportation sector that is practical to be used in Malaysia.

Selain B5, bincangkan kelebihan dan kelemahan penggunaan satu lagi tenaga bio yang boleh digunakan bagi sektor pengangkutan di Malaysia.

[5 marks/markah]

- [e] If you are Malaysia's energy minister, how can you promote the use of biofuel (including biodiesel) in Malaysia.

Sekiranya anda Menteri Tenaga Malaysia, bagaimana anda boleh menggalakkan penggunaan tenaga bio (termasuk biodiesel) di Malaysia.

[5 marks/markah]

2. [a] Malaysia is currently the second largest producer of palm oil in the world. In this regard, Malaysia generates huge quantity of solid biomass annually from the oil palm industry alone. Using a systematic approach, describe the potential bioenergy that can be generated from the solid biomass from the oil palm industry in Malaysia and also briefly describe the technology required for the conversion. Limit your discussion to only thermo-chemical conversion routes.

Kini Malaysia adalah pengeluar minyak kelapa sawit kedua terbesar di dunia. Dalam hal ini, Malaysia menghasilkan biojisim pepejal dalam kuantiti yang amat besar setiap tahun daripada industri kelapa sawit sahaja. Dengan menggunakan pendekatan yang sistematik, terangkan potensi penghasilan tenaga bio daripada biojisim pepejal yang dihasilkan daripada industri kelapa sawit di Malaysia dan juga terangkan secara ringkas teknologi yang diperlukan bagi penukaran tersebut. Hadkan perbincangan anda hanya kepada teknologi termo-kimia.

[10 marks/markah]

- [b] APEX Sdn. Bhd. is a company that produces bread. The company has one rotary oven for processing the products. One batch of 60kg dough required 20-25 min at 230-280°C for baking by burning LPG (C_3H_8). The oven consumed 6.5 kg of LPG per hour. The company would like to consider the use of renewable energy replacing the LPG. As a chemical engineer, you are required to assess its feasibility and partially design a gasifier using wood as source of fuel by answering the following questions:

APEX Sdn. Bhd. adalah satu syarikat yang menghasilkan roti. Syarikat tersebut mempunyai satu ketuhar putar bagi pemprosesan produk tersebut. Satu kelompok 60 kg adonan memerlukan 20-25 minit pada 230–280 °C bagi tujuan penyediaan roti dengan membakar LPG (C_3H_8). Ketuhar tersebut memerlukan 6.5 kg LPG setiap jam. Syarikat tersebut ingin mempertimbangkan penggunaan tenaga boleh diperbaharui bagi menggantikan LPG. Sebagai seorang jurutera kimia, anda dikehendaki untuk menilai kebolehlaksanaan dan merekabentuk sebahagian daripada penggas yang menggunakan kayu sebagai sumber bahan api dengan menjawab soalan-soalan berikut:

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- [i] Briefly describe two (2) types of gasifier.
Terangkan secara ringkas dua (2) jenis penggas.
[5 marks/markah]
- [ii] Calculate the amount of wood that is required to replace the LPG (on an hourly basis).
Kirakan kuantiti kayu yang diperlukan bagi menggantikan LPG (menggunakan asas satu jam).
[4 marks/markah]
- [iii] Calculate the cross sectional area for the gasifier.
Kirakan keratan rentas penggas.
[2 marks/markah]
- [iv] Calculate the amount of CO₂ savings per year assuming 8 hr operation per day and 320 days per year.
Kirakan pengurangan kuantiti CO₂ yang dibebaskan ke persekitaran setiap tahun berasaskan operasi 8 jam setiap hari dan 320 hari setiap tahun.
[4 marks/markah]

Note: The following data may be required:
Nota: Data berikut mungkin diperlukan:

Caloric value for LPG is 46.1 MJ/kg
Caloric value for producer gas from wood is 4.5 MJ/m³
Gas production from wood is 2.65 m³/kg
Cold gas efficiency can be taken as 72%
Specific gasification rate can be taken as 160 kg/h.m²
Gasifier cross sectional area = Feedstock consumption rate/specific gasification rate.

*Nilai kalori LPG adalah 46.1 MJ/kg
Nilai kalori bagi gas pengeluar daripada kayu adalah 4.5 MJ/m³
Penghasilan gas daripada kayu adalah 2.65 m³/kg
Kecekapan gas sejuk boleh diambil sebagai 72%
Kadar gasifikasi tentu boleh diambil sebagai 160 kg/j.m²
Keratan rentas penggas = Kadar penggunaan suapan/kadar gasifikasi tentu*

3. [a] Discuss the practicality of solar energy utilization in the Malaysian context.
Bincangkan kesesuaian penggunaan tenaga solar dalam konteks Malaysia.
[4 marks/markah]
- [b] Explain the reasons why solar cells have such low values of conversion efficiency.
Jelaskan sebab-sebab mengapa sel solar mempunyai nilai kecekapan penukaran yang rendah.
[4 marks/markah]

- [c] An engineer claimed to have constructed a thermal solar collector with reflecting concentrators that are able to concentrate the sun rays up to 1 million times. His calculation predicted that the receiver temperature would be around 12 460 K. With the sun surface temperature of 6000 K, on average 8 hours per day of sunlight with insolation of 1000 W/m^2 and assume an ideal receiver where by no conduction or convection losses occurred, would you approve the design of the thermal solar collector. Give reasons why.

Seorang jurutera mendakwa telah membina pengumpul solar haba dengan pantulan tertumpu yang mampu untuk menumpukan sinaran matahari sehingga 1 juta kali. Pengiraan beliau meramalkan bahawa suhu penerima adalah sekitar 12 460 K. Dengan suhu permukaan matahari 6000 K, purata 8 jam sehari cahaya matahari dengan isolasi 1000 W/m^2 dan menganggap penerima yang unggul, di mana tiada kehilangan melalui konduksian atau perolakan berlaku, adakah anda akan meluluskan rekabentuk pengumpul solar terma tersebut. Berikan sebab-sebab anda.

[4 marks/markah]

- [d] Identify and discuss reasons that could hamper the concentration of sun light (in terms of power densities) to be less than ideal.

Kenalpasti dan bincangkan sebab-sebab yang boleh menghalang pengumpulan cahaya matahari (dari segi ketumpatan kuasa) kurang dari keadaan unggul.

[4 marks/markah]

- [e] Why are solar concentrators often used in photovoltaic cell applications?

Mengapa pengumpul solar sering digunakan dalam aplikasi sel fotovoltik?

[2 marks/markah]

- [f] What are the principle difficulties in manufacturing single crystal silicon for the use in photovoltaic cells?

Apakah kesukaran utama dalam pembuatan kristal silikon tunggal untuk kegunaan dalam sel fotovoltik?

[2 marks/markah]

- [g] Describe using a diagram the essential features of an arrangement to heat indirectly the water of a domestic hot water system using a flat plate solar collector. In a typical system the flat plate collector is housed in a thermally insulated container with a glass cover, exposed to the radiation. Explain the action of the glass fronted container.

Huraikan dengan menggunakan gambar rajah, ciri-ciri penting untuk memanaskan air secara tidak langsung sistem air panas domestik dengan menggunakan pengumpul solar plat rata. Dalam sistem lazim pengumpul plat rata ditempatkan di dalam bekas yang ditebat dengan penutup kaca dan terdedah kepada sinaran. Terangkan tindakan bekas kaca.

[5 marks/markah]

4. [a] Briefly answer all the questions below:
Jawab semua soalan-soalan di bawah secara ringkas:
- [i] What is the main difference between a fuel cell and a battery?
Apakah perbezaan utama di antara sel bahan api dan bateri?
[2 marks/markah]
 - [ii] What are the products forms when the fuel is methanol?
Apakah produk-produk yang terhasil apabila bahan api metanol digunakan?
[2 marks/markah]
 - [iii] What other energy apart from electricity does a fuel cell produce?
Apakah tenaga lain selain daripada tenaga elektrik yang dihasilkan oleh sel bahan api?
[1 marks/markah]
 - [iv] What is the ionic conducting species in the DMFC?
Apakah spesis pengkonduksi ionik dalam DMFC?
[1 marks/markah]
 - [v] What is the name of the electrolyte used in the SOFC?
Apakah nama elektrolit yang digunakan dalam SOFC?
[1 marks/markah]
 - [vi] What fuel, apart from hydrogen, can the SOFC run on?
Apakah bahan api selain daripada hidrogen yang boleh digunakan oleh SOFC?
[1 marks/markah]
 - [vii] What is meant by the term CHP?
Apakah yang dimaksudkan dengan CHP?
[1 marks/markah]
 - [viii] What is meant by the term Fuel Crossover?
Apakah yang dimaksudkan dengan istilah Lintasan Bahan Api?
[1 marks/markah]
- [b] Draw a fully labelled cross section of a single membrane electrode assembly (MEA) for a proton exchange membrane (PEM) fuel cell. Label as many of the features as possible including: the supported catalyst, the gas diffusion electrodes, the electrolyte membrane, the fuel supply (H_2), the air supply (O_2), the formation of water and the load. Show how the catalyst is incorporated into the surface of the electrolyte. Use arrows to indicate the direction of flows of electrons, gases and water. Indicate the flow of ionic species in the electrolyte.
- Lukis dan labelkan keratan rentas lengkap pemasangan elektrod membran tunggal (MEA) bagi membran pertukaran proton (PEM) sel bahan api. Label sebanyak mungkin ciri-ciri yang termasuk mungkin tersokong, elektrod diffusi gas, membran elektrolit, bekalan bahan api (H_2), bekalan udara (O_2), pembentukan air dan beban. Tunjukkan bagaimana mangkin dimasukkan ke dalam permukaan elektrolit. Gunakan anak panah untuk tunjukkan arah aliran elektron, gas dan air. Tunjukkan juga aliran spesis ion dalam elektrolit.*

[6 marks/markah]

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- [c] From the information in the datasheet, calculate the theoretical maximum efficiency of a PEM fuel cell running on hydrogen at 25 °C.

Kirakan kecekapan maksimum teori sel bahan api PEM dengan menggunakan hidrogen pada 25 °C.

Given that Faraday constant, $F = 9.6485 \times 10^4 \text{ C mol}^{-1}$ and gas constant, $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$

Diberi pemalar Faraday, $F = 9.6485 \times 10^4 \text{ C mol}^{-1}$ dan pemalar gas, $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$

[4 marks/markah]

- [d] Write down the half cell reactions for the SOFC running on hydrogen at 800°C. Use the “Right Hand Side (RHS) – Left Hand Side (LHS)” to determine the EMF and the overall reaction. Show all your steps.

Tuliskan tindakbalas separa sel untuk SOFC yang menggunakan hidrogen pada 800 °C. Gunakan "Sebelah Tangan Kanan (RHS) - Sebelah Tangan kiri (LHS)" untuk menentukan EMF dan tindakbalas keseluruhan. Tunjukkan semua langkah-langkah anda.

[5 marks/markah]