UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

EBS 323/3 – Pyrometallurgy
[Pirometalurgi]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains TEN printed pages and ONE page APPENDIX before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEPULUH muka surat yang bercetak dan SATU muka surat LAMPIRAN sebelum anda memulakan peperiksaan ini.]

This paper contains SEVEN questions.
[Kertas soalan ini mengandungi TUJUH soalan.]

Instruction: Answer **FIVE** questions. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

Answer to any question must start on a new page.
[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

1. [a] With a neat sketch, discuss the working principles of a RH degasser. What are the major benefits of its use in a steel making process?

Dengan bantuan lakaran, bincangkan prinsip kerja RH penyahgas. Apakah faedah utama kegunaan prinsip ini dalam proses pembuatan keluli?

(60 marks/*markah*)

[b] Mention the important kinetic considerations and the possible ways to improve the overall process kinetics during the operation of industrial degassing and decarburization units?

Nyatakan kepentingan keseimbangan kinetik dan cara yang dapat meningkatkan keseluruhan proses kinetik sepanjang operasi industri penyahgas dan unit penyahkarbonan?

(40 marks/*markah*)

2. [a] One blast furnace of working volume 1500m^3 produces 125 tons of hot metal per hour. The average hot metal composition is: (Fe = 93%, C = 4.2%, Si = 1.6%, Mn = 0.8%). The furnace uses hematite ore (Fe_2O_3 = 90%, SiO_2 = 7%, Al_2O_3 = 2%, MnO = 1%), flux ($CaCO_3$ = 95%, SiO_2 = 5%), coke (C = 90%, SiO_2 = 8%, Al_2O_3 = 2%).

Assume:

(i) All the iron ore charged gets reduced by carbon.

(ii) Ore, coke, and flux are moisture free.

(iii) The final slag contains 50% CaO

(iv) Coke rate = 500 kg/thm

(v) Atomic weights given : Fe = 56, Si = 28, Ca = 40, Mn = 55, C = 12, O = 16

Calculate :

(i) Amount of iron ore used in tons per day.

(ii) Basicity (CaO/SiO_2) of the final slag.

(iii) Percentage of the total SiO_2 reduced inside the furnace.

(iv) Productivity of the furnace (in $t/d/m^3$).

Satu relau bagas dengan isipadu kerja 1500 m^3 menghasilkan 125 tan logam panas per jam. Komposisi purata logam panas adalah (Fe = 93%, C = 4.2%, Si = 1.6%, Mn = 0.8%). Relau ini menggunakan bijih hematite (Fe_2O_3 = 90%, SiO_2 = 7%, Al_2O_3 = 2%, MnO = 1%), flux ($CaCO_3$ = 95%, SiO_2 = 5%), arang (C = 90%, SiO_2 = 8%, Al_2O_3 = 2%).

Anggapkan:

(i) *Semua bijih besi yang dimasukkan diturunkan oleh karbon.*

(ii) *Bijih, arang batu dan flux adalah bebas kelembapan.*

(iii) *Kandungan akhir jermang mengandungi 50% CaO.*

(iv) *Kadar arang batu = 500kg/thm.*

(v) *Berat atom diberi: Fe = 56, Si = 28, Ca = 40, Mn = 55, C = 12, O = 16*

Kirakan:

(i) *Jumlah bijih besi yang digunakan dalam tan/hari.*

(ii) *Kebesan (CaO/SiO_2) jermang akhir.*

(iii) *Peratusan jumlah SiO_2 diturunkan dalam relau.*

(iv) *Pengeluaran relau ($in/t/d/m^3$).*

(40 marks/*markah*)

[b] Answer in brief the following (any two):

Pilih dan jawab secara ringkas mana-mana dua daripada soalan berikut:

(i) What are the major roles of Boudouard reaction towards the heat demand and reduction behavior in a blast furnace?

Apakah peranan utama tindakbalas Boudouard terhadap haba dan penurunan dalam relau bagas?

(20 marks/*markah*)

(ii) What is the Alkali Cycle in an iron blast furnace and how does it affect the burden descent in the furnace?

Apakah yang dimaksudkan kitaran alkali di dalam relau bagas besi dan bagaimanakah ia memberi kesan kepada penurunan beban di dalam relau?

(20 marks/*markah*)

(iii) With the help of the Ellingham's diagram, discuss the possibilities of getting Al, Cu, and Mg in the hot metal assuming that the charge contains Al_2O_3, CuO, and MgO.

Dengan bantuan gambarajah Ellingham, bincangkan kebolehan dalam mendapatkan Al, Cu dan Mg dalam logam panas dengan menganggap ia mengandungi Al_2O_3, CuO, dan MgO.

(20 marks/*markah*)

3. [a] An LD converter is treating 130 tons of hot metal (containing C = 4.2%, Si = 1.8%, Mn = 0.8%, P = 0.1%, rest being iron) to produce steel (with C = 0.3%, Si = 0.4%, Mn = 0.7%, P = 0.01%). If pure lime (CaO) is added to the converter to produce a slag with 40% CaO and the slag has 10% FeO, calculate:

(i) Composition of the slag produced.

(ii) Weight of the slag produced in tons.

(iii) Theoretical oxygen consumption in Nm^3 per ton of hot metal.

Penukar LD 130 tan logam panas (mengandungi C = 4.2%, Si = 1.8%, Mn = 0.8%, P = 0.1%, selebihnya adalah besi) untuk menghasilkan logam (dengan C = 0.3%, Si = 0.4%, Mn = 0.7%, P = 0.01%). Jika kapur tulen (CaO) ditambahkan kepada pengubah untuk hasilkan jermang dengan 40% CaO dan jermang mengandungi 10% FeO, kirakan:

(i) Komposisi jermang yang dihasilkan.

(ii) Berat jermang yang dihasilkan dalam tan.

(iii) Penggunaan oksigen secara teori dalam Nm^3 per tan logam panas.

(60 marks/*markah*)

[b] Mentioning the major chemical reactions involved in the sulphur transfer during iron and steel making, what are the necessary process conditions to be applied to produce low sulphur hot metal and steel. With the help of Whitman's Two Film Theory, illustrate the mechanism of sulphur transfer between liquid slag and liquid hot metal or steel.

Nyatakan tindakbalas kimia utama yang terlibat dalam pemindahan sulfur semasa pembuatan besi dan keluli, apakah keadaan proses yang perlu diaplikasikan untuk menghasilkan logam panas dan keluli rendah sulfur. Dengan menggunakan teori Whitman's Two Film, gambarkan mekanisma pemindahan sulfur di antara jermang cair dan logam panas cair atau keluli.

(40 marks/*markah*)

4. Write short notes on (any four):

Tuliskan hanya empat nota ringkas yang berikut:

[a] Henry's Law and its usefulness in steel making.

Hukum Henry dan kegunaannya dalam pembuatan aloi.

(25 marks/*markah*)

[b] Phosphate capacity of slag and its use in steel making.

Kapasiti fosfat jermang dan kegunaannya dalam pembuatan keluli.

(25 marks/*markah*)

[c] The principle of inclusion modification in steel with Ca-Si treatment.

Prinsip yang diambil kira dalam pengubahsuaian keluli dengan rawatan Ca-Si.

(25 marks/*markah*)

[d] A comparison among the top blown, bottom blown, and combined blown processes in steel making in terms of kinetics, gas content in product, Fe content in slag, and metallic yield.

Perbandingan di antara tiupan atas, tiupan tengah dan gabungan tiupan dalam pembuatan keluli dari segi kinetik, kandungan gas dalam hasil pengeluaran, kandungan Fe dalam jermang dan hasil berlogam.

(25 marks/*markah*)

[e] Segregation during steel making and the means to overcome this problem.

Pengasingan semasa pembuatan keluli dan cara-cara untuk mengatasi masalah tersebut.

(25 marks/*markah*)

5. [a] With the necessary process flowsheet, explain in brief the principles of electrolytic refining of tin.

Dengan menggunakan proses helai aliran, jelaskan secara ringkas prinsip elektronik penapisan timah.

(50 marks/*markah*)

[b] Discuss the role of Cryolite in Aluminium electrolysis in a Hall-Heroult cell mentioning the necessary chemical reactions involved.

Bincangkan peranan Cryolite dalam elektrolisis aluminium dalam sel Hall-Heroult, nyatakan tindakbalas kimia terlibat.

(50 marks/*markah*)

6. [a] What is the basic principle if zone refining to produce ultra-pure materials?

Apakah prinsip asas zon penapisan untuk menghasilkan bahan ultra tulen?

(40 marks/*markah*)

[b] The following equilibrium data have been determined for the reaction:

Persamaan berikut adalah ditentukan bagi tindakbalas

$$NiO(s) + CO(g) = Ni(s) + CO_2(g)$$

T(°C)	663	716	754	793	852
K x 10^{-3}	4.535	3.323	2.554	2.037	1.577

(i) Find ΔH°, K, and ΔG° at 1000K by using a plot.

Cari ΔH°, K, dan ΔG° pada suhu 1000K dengan menggunakan plot.

(30 marks/*markah*)

(ii) Would an atmosphere containing 15% CO_2, 5% CO, and 80% N_2 oxidize nickel at 1000K?

Bolehkah atmosfera mengandungi 15% CO_2, 5% CO, dan 80% N_2 Nikel Oksida pada suhu 1000K?

(30 marks/*markah*)

7. [a] The carbon reduction of Nb_2O_3 at 1200K shows the following:

Penurunan karbon pada suhu 1200K ditunjukkan seperti berikut:

$$Nb_2O_3(s) + 5C(s) = 2Nb(s) + 5CO(g) \quad \Delta G^\circ = + 68.85 \text{ kcal}$$

meaning that this reaction is thermodynamically not feasible at 1200°K. However, can it be made possible thermodynamically at that temperature by manipulating the process parameters?

tindakbalas tersebut secara termodinamiknya tidak munasabah pada suhu 1200K. Bagaimanakah ia boleh menjadi munasabah secara termodinamiknya pada suhu tersebut dengan mengubah parameter-parameter proses?

(50 marks/*markah*)

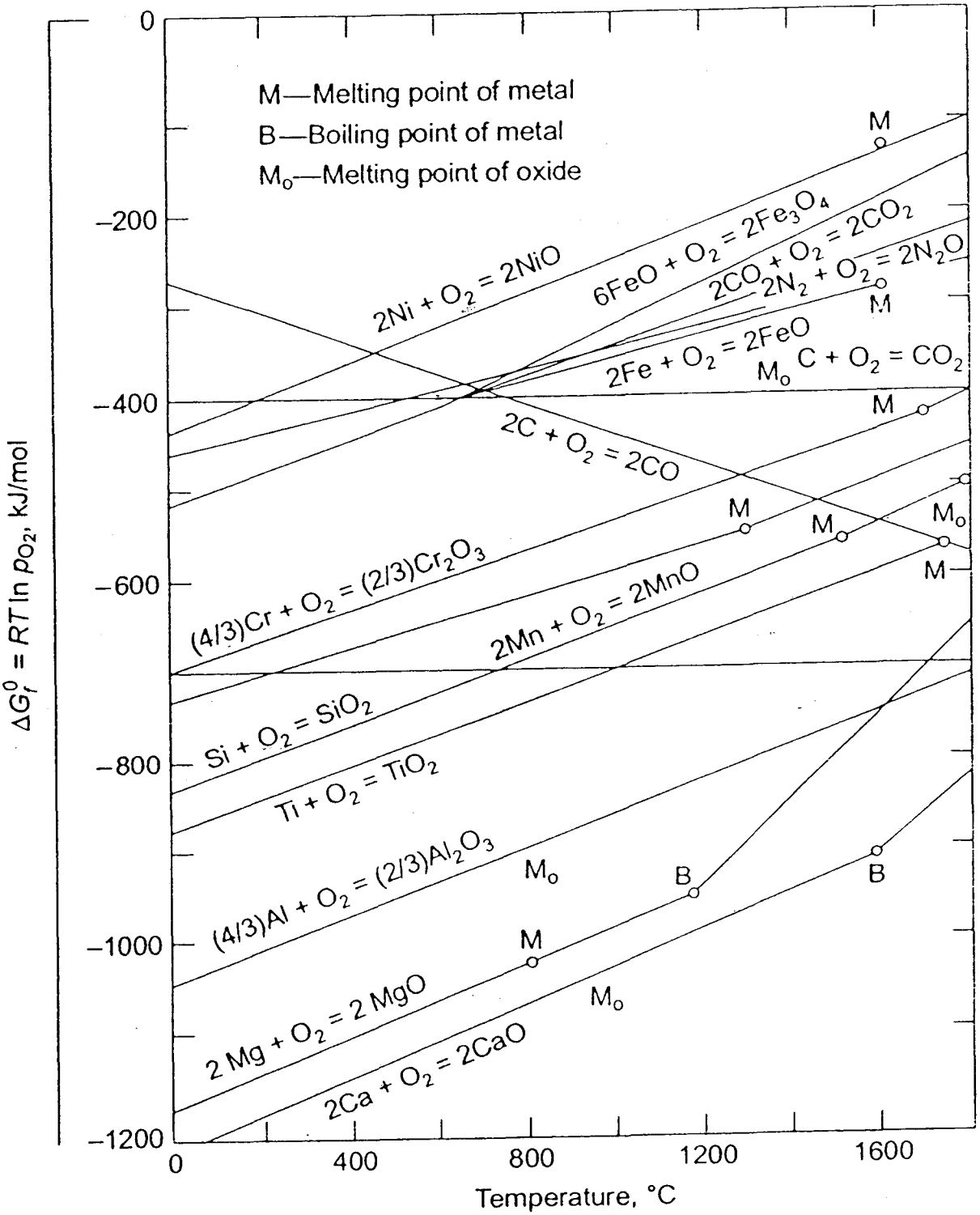
[b] Assume that a liquid metal is kept at a constant temperature of 1000°K at open atmosphere for a certain length of time for refining. The dissolved hydrogen content in the liquid metal after refining is measured as 0.005%. If the hydrogen content is to be brought down now to 0.001%, how the atmosphere is to be controlled?

Anggapkan sejenis cecair logam diletakkan pada suhu tetap 1000K pada atmosfera terbuka pada jangka masa tertentu untuk proses penulinan. Kandungan gas terlarut dalam cecair logam selepas proses penulinan adalah 0.005%. Jika kandungan hidrogen terlarut diturun kepada 0.001%, bagaimanakah suhu atmosfera dapat dikawal?

(50 marks/*markah*)

- oooOooo -

APPENDIX / *LAMPIRAN*



Standard free energy of formation of some oxides as function of temperature.