
UNIVERSITI SAINS MALAYSIA

Supplementary Semester Examination
Academic Session 2007/2008

June 2008

IEK 101 – Chemical Process Calculations
[Penghitungan Proses Kimia]

Duration: 3 hours
[Masa : 3 jam]

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

Answer FIVE questions. All questions can be answered either in Bahasa Malaysia OR English.

Sila pastikan bahawa kertas peperiksaan in mengandungi SEPULUH muka surat yang bercetak sebelum anda memulakan peperiksaan ini.

Jawab LIMA soalan. Semua soalan boleh dijawab dalam Bahasa Malaysia ATAU Bahaga Inggeris.

1. Answer all parts of this question.

(a) The speed, v , of a water wave in shallow water of depth h is

$$v = A^{1/2} h^{1/2}$$

where A is a constant. Find the dimensions and units of A in the SI system.

(10 marks)

(b) Determine if the following equation is dimensionally correct:

$$S = S_0 + v_0 t + (1/2) a t^2; \text{ where}$$

S : distance at time t

S_0 : distance at time $t = 0$

v_0 : speed at time $t = 0$

a : constant acceleration

(10 marks)

2. A solution of brine contains 19.6g of sodium (Na). The weight fraction of Na in the solution is 0.78, while the volume of the solution = 1.234 L. MW of Na = 23. Calculate:

(a) weight of the water in g.

(5 marks)

(b) density of the solution in g/cm^3

(5 marks)

(c) M , molarity of sodium.

(5 marks)

(d) Parts per million, ppm of Na.

(5 marks)

3. Wine making involves a series of very complex reactions most of which are performed by microorganisms. The starting concentration of sugars determines the final alcohol content and sweetness of the wine. The specific gravity of the starting stock is therefore adjusted to achieve desired quality of wine.

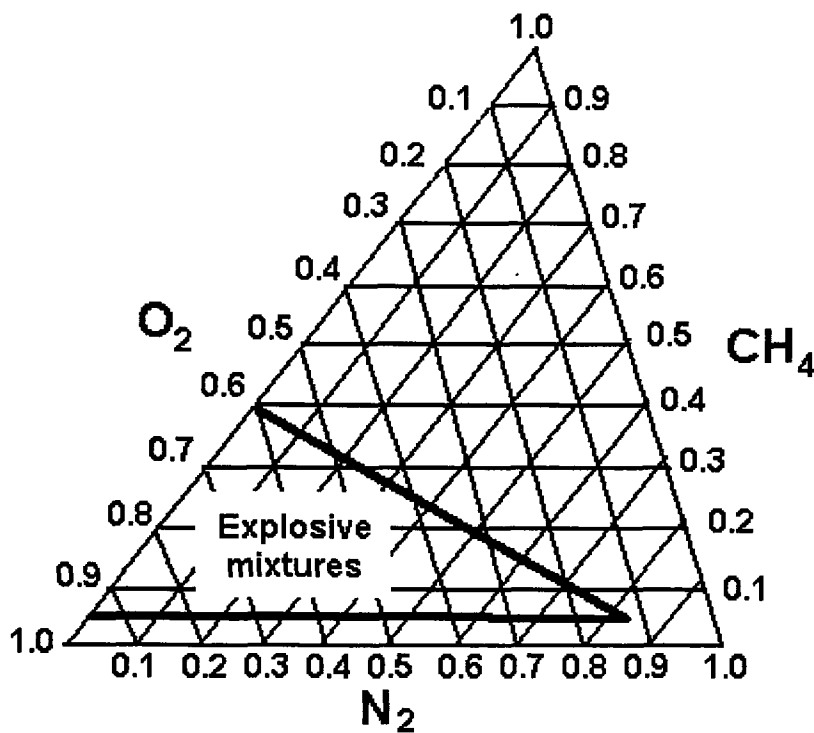
A starting stock solution has a specific gravity of 1.075 and contains 12.7 wt% sugar. If all the sugar is assumed to be $C_{12}H_{22}O_{11}$, determine

- (a) kg sugar/kg H_2O (6 marks)
- (b) lb solution/ft³ solution (7 marks)
- (c) g sugar/L solution (7 marks)

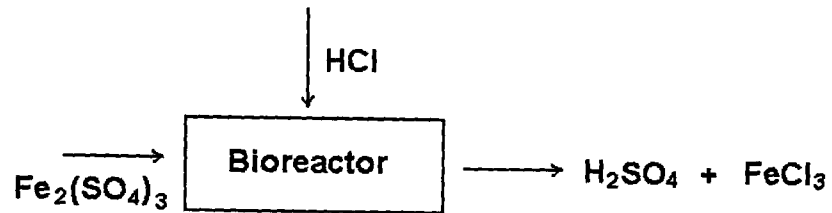
Use a basis of 100 kg of starting stock solution. [AW C:12, H:1, O:16]

4. A mixture contains 10 g-mol nitrogen, 25 g-mol oxygen and 65 g-mol methane. A company producing combustion materials need to generate an explosive mixture for construction purposes. Two engineers were assigned for this task. Engineer A proposed to add another 35 g-mol of nitrogen and 50 g-mol of oxygen into the mixture, but reduce another 35 g-mol of methane from the mixture. Engineer B proposed to just double the amount of oxygen in the mixture, and maintains the amounts of nitrogen and methane. Using the explosive pyramid below, determine which proposal to be used.

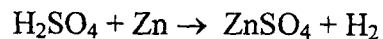
(20 marks)



5. A biochemical process involves a reaction as indicated by the diagram below. 80 kg of $\text{Fe}_2(\text{SO}_4)_3$ was used to react with 13 kg of HCl , producing $\text{H}_2\text{SO}_4 + \text{FeCl}_3$. [MW: Fe = 56; O = 16; S = 32; Cl = 35].



- (a) Provide a stoichiometric equation for the above reaction. (5 marks)
- (b) Determine the limiting and excess reactant. (5 marks)
- (c) Assuming that all the HCl was used, how many kg of $\text{Fe}_2(\text{SO}_4)_3$ reacted? (5 marks)
- (d) Assuming that the reaction reacted stoichiometrically, how many kg of FeCl_3 and H_2SO_4 was produced? (5 marks)
6. An old way of producing hydrogen gas in the laboratory was by the reaction of sulfuric acid with zinc metal:



How many grams of sulfuric acid solution (98%) must act on an excess of zinc to produce $12.0 \text{ m}^3/\text{hr}$ of hydrogen at standard conditions. Assume all the acid used completely reacts.

(20 marks)

7. A steam needs to be trapped along the processing line. It contains superheat mixtures. Three steam traps are being considered. They are the thermodisc steam trap, liquid-expansion trap and inverted-bucket trap.
- (a) Which one would be the most appropriate and why? (4 marks)
- (b) What are its advantages? (8 marks)
- (c) What are its disadvantages? (8 marks)

1. Jawab semua bahagian dalam soalan ini.

(a) Kelajuan, v , ombak air di dalam air yang cetek dengan kedalaman h adalah

$$v = A^{1/2} h^{1/2}$$

dimana A adalah konstan. Dapatkan dimensi dan unit untuk A di dalam sistem SI.

(10 markah)

(b) Tentukan samada persamaan berikut adalah betul dari segi dimensi::

$$S = S_0 + v_0 t + (1/2) a t^2; \text{ where}$$

S : jarak pada masa t

S_0 : jarak pada masa $t = 0$

v_0 : kelajuan pada masa $t = 0$

a : pecutan konstan

(10 markah)

2. Satu larutan air masin mengandungi 19.6g sodium (Na). Pecahan berat Na di dalam larutan tersebut ialah 0.78, manakala isipadu larutan adalah 1.234 L. Berat molekul Na = 23. Kirakan:

(a) berat air dalam unit g.

(5 markah)

(b) ketumpatan larutan dalam g/cm^3

(5 markah)

(c) M , molariti untuk Na.

(5 markah)

(d) Bahagian dalam sejuta (ppm) untuk Na.

(5 markah)

3. Proses pembuatan wain melibatkan tindak balas yang kompleks, yang melibatkan penggunaan mikroorganisma. Kepekatan awal gula menentukan kandungan alkohol dan kemanisan wain tersebut. Maka, gravity spesifik stok awal perlu dikawal untuk memperolehi kualiti yang yang dikehendaki.

Larutan stok awak mempunyai graviti spesifik 1.075 dan mengandungi 12.7 % berat gula. Jika kesemua gula adalah $C_{12}H_{22}O_{11}$, tentukan

(a) kg gula/kg H_2O

(6 markah)

(b) lb larutan/kaki³ larutan

(7 markah)

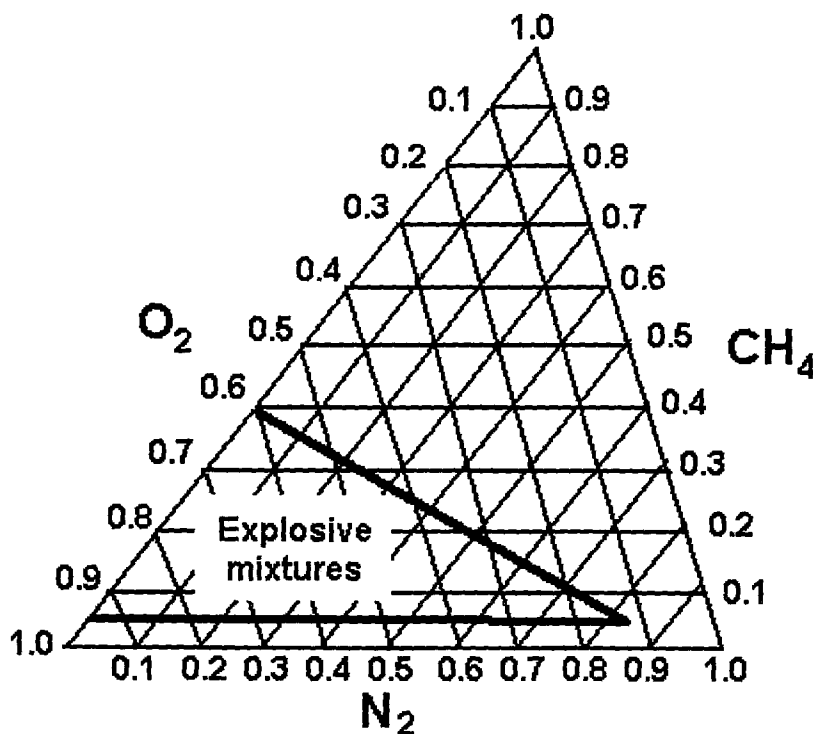
(c) g gula/L larutan

(7 markah)

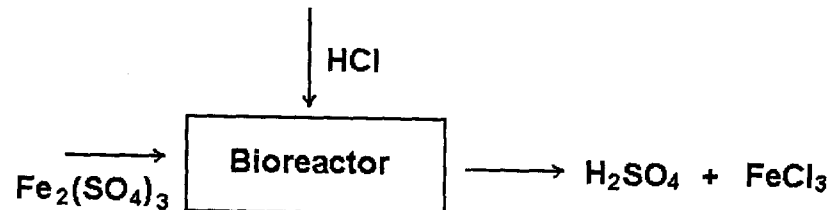
Gunakan 100 kg larutan stok awal sebagai basis. [Berat atom C:12, H:1, O:16]

4. Satu campuran mengandungi 10 g-mol nitrogen, 25 g-mol oksigen dan 65 g-mol metana. Satu syarikat yang menghasilkan bahan terbakar perlu menghasilkan satu campuran meletup untuk tujuan pembinaan. Dua jurutera dilantik untuk tujuan ini. Engineer A mencadangkan untuk menambahkan 35 g-mol nitrogen and 50 g-mol oksigen kepada campuran asal, tetapi mengurangkan 35 g-mol metana daripada campuran asal. Jurutera B mencadangkan untuk menggandadua kandungan oksigen dalam campuran asal dan mengekalkan kandungan nitrogen dan metana. Dengan menggunakan piramid letupan berikut, tentukan cadangan siapa yang patut digunakan.

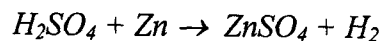
(20 markah)



5. Satu proses biokimia melibatkan tindak balas seperti di bawah. 80 kg $Fe_2(SO_4)_3$ diperlukan untuk bertindak balas dengan 13 kg HCl, menghasilkan H_2SO_4 + $FeCl_3$. [Berat molekul: Fe = 56; O = 16; S = 32; Cl = 35].



- (a) Berikan persamaan stoikiometrik untuk tindak balas di atas.
(5 markah)
- (b) Tentukan reaktan terhad dan reaktan berlebihan.
(5 markah)
- (c) Andaikan semua HCl digunakan, berapa kg $Fe_2(SO_4)_3$ yang telah bertindakbalas?
(5 markah)
- (d) Andaikan tindak balas adalah secara stoikiometrik, berapa kg $FeCl_3$ dan H_2SO_4 yang telah terhasil?
(5 markah)
6. Suatu kaedah lampau untuk menghasilkan hidrogen dalam makmal adalah melalui tindakbalas asid sulfuric dengan logam zink:



Berapa g larutan asid sulfuric (98%) yang mesti bertindakbalas dengan zink berlebihan untuk menghasilkan $12.0 \text{ m}^3/\text{jam}$ hydrogen pada keadaan standard? Andaikan semua asid telah bertindakbalas.

(20 markah)

7. *Suatu stim perlu diperangkap dalam sistem pemprosesan. Ia mengandungi campuran haba-lampau (superheat). Tiga perangkap stim akan dipertimbang, iaitu perangkap stim termodisk, perangkap stim pengembangan cecair dan perangkap stim baldi songsang.*

(a) *Manakah perangkap stim yang paling sesuai dan mengapa?* (4 markah)

(b) *Apakah kelebihan-kelebihan perangkap stim ini?* (8 marksah)

(c) *Apakah keburukan-keburukan perangkap stim ini?* (8 markah)