
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2007/2008 Academic Session

**KAA 508 – Environmental Pollution and Monitoring Techniques
[Pencemaran Alam Sekitar dan Teknik Pemantauan]**

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **EIGHT** printed pages before you begin.

Instructions:

Answer **FIVE** (5) questions only.

Begin your answer on a new page.

You may answer either in Bahasa Malaysia or in English.

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

In the event on any discrepancies, the English version shall be used

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1. Both the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) tests are widely used to measure the pollutional strength of domestic and industrial wastewaters.

(a) Why do the COD and BOD tests usually give different results for the same waste?

(6 marks)

(b) What could be inferred from the following analytical results concerning the relative ease of biodegradability of each wastewater?

Wastewater	BOD ₅ (mgL ⁻¹)	COD (mgL ⁻¹)
A	250	300
B	100	500
C	120	250

(5 marks)

(c) Indicate whether COD results would probably be higher, lower or the same as the true value under the following conditions. Explain why.

(i) Mercuric sulphate was not added.

(ii) Silver sulphate was not added.

(iii) The sample was digested for only one hour.

(9 marks)

2. In selecting a suitable site for a factory, the impact of the industrial effluent on the water quality of a river must be considered. The flow rate of the effluent and river is 0.5 and 9.0 m³ s⁻¹, respectively. The temperature of the effluent and river is 30 and 28 °C, respectively. The BOD₅ value for the effluent and river is 100 and 1.0 mg L⁻¹, respectively. The dissolved oxygen (DO) in river water is 5.0 mg L⁻¹ before mixing with the effluent, which contains 1.0 mg L⁻¹ DO.

(a) Sketch the oxygen sag curve.

(6 marks)

(b) Estimate the critical time when the oxygen deficit is maximum. Determine the lowest DO concentration.

(6 marks)

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- (c) Estimate the percentage of reduction of the effluent BOD₅ that has to be implemented if the minimum DO in river water is to attain 4.5 mg L⁻¹.

(8 marks)

Given:

Streeter Phelps equation:

$$D_t = \frac{k_1}{k_2 - k_1} L_u (e^{-k_1 t} - e^{-k_2 t}) + D_0 e^{-k_2 t}$$

$$k_1(T) = 0.30(1.047)^{T-20} \text{ day}^{-1}$$

$$k_2(T) = 0.70(1.015)^{T-20} \text{ day}^{-1}$$

$$L_u = 1.5 \times \text{BOD}_5 \text{ mg L}^{-1}$$

Saturated DO concentration = 7.9 mg L⁻¹
in the temperature range
of 28 – 29 °C

3. In developing marine water quality standard for Malaysia, three organic pollutants have been included in the criteria. These are oil and grease, phenols and tributyltin.

- (a) Suggest sampling and monitoring programmes in term of locations to safeguard the sensitivity to the aquatic ecosystems in Malaysia such as coral reefs, mangrove swamps, recreational beaches as well as pristine deep-sea environments.

(4 marks)

- (b) For the ASEAN Marine Water Quality Criteria, the limit for oil and grease is 0.14 mg/L. Suggest a complete procedure to analyse oil and grease in marine water samples in order to be able to monitor oil and grease contamination based on the criteria limit.

(6 marks)

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- 4 -

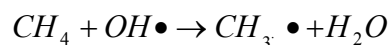
- (c) Total phenols include 10 phenolic compounds under the USEPA priority pollutants. The limit for total phenols is 0.12 mg/L under the ASEAN Marine Water Quality Criteria.
- (i) Write down all 10 phenolic compounds listed under the USEPA priority pollutants.
- (ii) Describe how these phenolic compounds were analysed from the river water samples as described in the lecture. (10 marks)
4. (a) Describe the site selection and monitoring strategies in inland water quality monitoring. (10 marks)
- (b) Describe and discuss the various preservation methods in water sampling. (10 marks)
5. (a) Derive the equation for the box model. State the assumptions. (8 marks)
- (b) A chemical spill occurs in a small town (1 km x 1 km) in a valley. During the incident, 16,200 kg of methyl ethyl ketone (C_4H_8O) evaporates over a period of 3 h. Assume the following:
- The town is bounded on two sides by hills 1000 m apart.
 - The wind speed is 0.5 m s^{-1} .
 - An inversion layer exists to a height of 50 m.
 - The initial methyl ethyl ketone (MEK) concentration is zero.
- Using the box model,
- (i) estimate how long it takes for the MEK concentration to reach $600 \mu\text{g m}^{-3}$ and
- (ii) determine the steady-state MEK concentration. (12 marks)

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6. (a) Describe the role of $\text{OH}\bullet$ radical in photochemical smog.

(10 marks)

- (b) Free radicals such as $\text{OH}\bullet$ are very reactive and it is very difficult to measure their concentrations. An estimate of the $\text{OH}\bullet$ concentration in the atmosphere can be obtained from knowing the half-life of CH_4 in the atmosphere. Consider the following reaction:



The rate equation is given by

$$\frac{d[\text{CH}_4]}{dt} = -k[\text{CH}_4][\text{OH}\bullet]$$

where the rate constant, k , as a function of temperature is

$$k = 3.5 \times 10^8 \exp\left(-\frac{4500}{T}\right) \text{m}^3 \text{mol}^{-1} \text{s}^{-1}$$

Estimate the $\text{OH}\bullet$ concentration at 300 K assuming that the $\text{OH}\bullet$ concentration is constant and the half-life of CH_4 is 10 years.

(10 marks)

1. Ujian tuntutan oksigen biokimia (BOD) dan tuntutan oksigen kimia (COD) digunakan dengan luasnya untuk menyukat kekuatan pencemaran bagi air buangan domestik dan industri.

(a) Mengapa ujian COD dan BOD biasanya menghasilkan keputusan yang berbeza bagi air buangan yang sama?

(6 marks)

(b) Apakah yang dapat disimpulkan daripada keputusan analisis yang berikut mengenai kesenangan relatif keterbiouraian setiap air buangan?

Air buangan	BOD ₅ (mg L ⁻¹)	COD (mg L ⁻¹)
A	250	300
B	100	500
C	120	250

(5 markah)

(c) Nyatakan sama ada keputusan COD akan menjadi lebih tinggi, lebih rendah atau sama dengan nilai sebenar di bawah keadaan yang berikut. Terangkan sebabnya

(i) Merkurik sulfat tidak ditambah.

(ii) Argentum sulfat tidak ditambah.

(iii) Sampel dihadamkan selama sejam sahaja.

(9 markah)

2. Untuk memilih tapak yang sesuai untuk sebuah kilang, impak efluen industri terhadap kualiti air sebatang sungai mesti dipertimbangkan. Kadar aliran efluen kilang dan sungai masing-masing adalah 0.5 dan 9.0 m³ s⁻¹. Suhu efluen dan air sungai masing-masing adalah 30 dan 28 °C. Nilai BOD₅ bagi efluen dan air sungai masing-masing adalah 100 dan 1.0 mg L⁻¹. Oksigen terlarut (DO) dalam air sungai adalah 5.0 mg L⁻¹ sebelum bercampur dengan efluen yang bernilai DO sejumlah 1.0 mg L⁻¹.

(a) Lakarkan lengkungan 'sag' oksigen.

(6 markah)

- 8 -

- (b) Anggarkan masa genting apabila kekurangan oksigen adalah maksima. Tentukan kepekatan DO yang paling rendah. (6 markah)
- (c) Anggarkan peratusan pengurangan BOD₅ efluen yang mesti dilaksanakan supaya DO minima dalam air sungai mencapai 4.5 mg L⁻¹. (8 markah)

Diberikan:

Persamaan Streeter Phelps:

$$D_t = \frac{k_1}{k_2 - k_1} L_u (e^{-k_1 t} - e^{-k_2 t}) + D_0 e^{-k_2 t}$$

$$k_1(T) = 0.30(1.047)^{T-20} \text{ hari}^{-1}$$

$$k_2(T) = 0.70(1.015)^{T-20} \text{ hari}^{-1}$$

$$L_u = 1.5 \times \text{BOD}_5 \text{ mg L}^{-1}$$

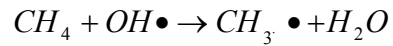
Kepekatan DO tepu dalam julat suhu 28 – 29 °C = 7.9 mg L⁻¹

3. Semasa pembangunan piawai kualiti air laut untuk Malaysia, tiga pencemar organik telah disenaraikan. Pencemar ini ialah minyak dan gris, fenol dan tributyl timah.
- (a) Cadangkan program pensampelan and pemantauan dari segi lokasi untuk menjaga dari pencemaran terhadap ekosistem akuatik di Malaysia seperti kawasan terumbu karang, paya bakau, pantai rekreasi dan persekitaran bersih laut dalam. (4 markah)
- (b) Untuk Kriteria Kualiti Air Laut ASEAN, had pencemaran bagi minyak dan gris adalah 0.14 mg/L. Cadangkan satu tatacara penuh untuk analisis minyak dan gris di dalam air laut supaya boleh memantau pencemaran minyak dan gris berdasarkan had kriteria tersebut. (6 markah)

- (c) Jumlah fenol adalah termasuk 10 sebatian fenol di bawah senarai pencemar utama USEPA. Had pencemaran bagi jumlah fenol adalah 0.12 mg/L di bawah Kriteria Kualiti Air Laut ASEAN.
- (i) Tulis semua 10 sebatian fenol yang tersenarai di bawah pencemar utama USEPA tersebut.
- (ii) Perikan bagaimana sebatian fenol ini di analisis dari sampel air sungai seperti yang diterangkan di dalam kuliah. (10 markah)
4. (a) Huraikan strategi penilaian tapak dan pemantauan dalam pemantauan kualiti air. (10 markah)
- (b) Huraikan dan bincangkan beberapa kaedah pemeliharaan dalam pensampelan air. (10 markah)
5. (a) Terbitkan persamaan bagi model kotak. Nyatakan andaian-andaian yang dibuat. (8 markah)
- (b) Suatu tumpahan kimia berlaku di sebuah bandar kecil (1 km x 1 km) yang terletak di lembah. Semasa peristiwa itu, sejumlah 16,200 kg metil etil keton (C_4H_8O) meruap dalam tempoh 3 jam. Anggap yang berikut:
- Bandar itu dibatasi di dua sisi oleh bukit yang jarak perpisahannya adalah 1000 m.
 - Laju angin adalah 0.5 m s^{-1} .
 - Lapisan songsangan suhu wujud pada ketinggian 50 m.
 - Kepekatan metil etil keton (MEK) awal adalah sifar.
- Dengan menggunakan model kotak,
- (i) anggarkan berapa lama untuk kepekatan MEK mencapai $600 \mu\text{g m}^{-3}$, dan
- (ii) tentukan kepekatan MEK pada keadaan mantap. (12 markah)

6. (a) Huraikan peranan radikal $\text{OH}\bullet$ dalam asbut fotokimia. (10 markah)

- (b) Radikal bebas seperti $\text{OH}\bullet$ sangat reaktif. Oleh itu, adalah sangat sukar untuk menyukat kepekatan mereka. Kepekatan $\text{OH}\bullet$ dalam atmosfera dapat dianggarkan daripada pengetahuan setengah hayat CH_4 dalam atmosfera. Pertimbangkan tindak balas berikut:



Persamaan kadar adalah

$$\frac{d[\text{CH}_4]}{dt} = -k[\text{CH}_4][\text{OH}\bullet]$$

dengan pemalar kadar, k , pelbagai fungsi suhu dinyatakan dengan

$$k = 3.5 \times 10^8 \exp\left(-\frac{4500}{T}\right) \text{m}^3 \text{mol}^{-1} \text{s}^{-1}$$

Anggarkan kepekatan $\text{OH}\bullet$ pada 300 K dengan menganggap bahawa kepekatan $\text{OH}\bullet$ adalah tetap dan setengah hayat bagi CH_4 adalah 10 tahun.

(10 markah)