UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

KAT 341 – Pollution And Environmental Chemistry
[Kimia Pencemaran Dan Alam Sekitar]

Duration : 3 hour
[Masa : 3 jam]

Please check that this examination paper consists of **TWENTY TWO** printed pages before you begin the examination.

Instruction:-

Answer **FIVE** questions only . Answer **THREE** questions from section A and **TWO** questions from section B

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.

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Section A

1. a) Two organic pollutants A and B had accidentally been discharged into a waterway. Pollutant A is known to have high octanol-water partition coefficient (K_{ow}) and soil organic carbon-water partition coefficient (K_{oc}). Pollutant B is the opposite of A with low K_{ow} and low K_{oc}.

   i) Predict the fate of each of these pollutants in the aquatic environment.

   ii) Analysis of cockles which have been exposed to A for a few days results in an average value of 15.06 $\mu g\ g^{-1}$. Assuming that the depuration rate constant (β) for A is 0.09 day^{-1}, estimate the time needed for the depuration of A by cockles to reach 5 $\mu g\ g^{-1}$.

   (12 marks)

   b) Explain briefly why anthropogenic activities such as deforestation and agricultural activities are considered as factors leading to increased water pollution.

   (8 marks)

2. a) Water quality index (WQI) is introduced to indicate the degree of pollution of a water body without invoking all the values of water quality parameters. Malaysian Department of Environment (DOE) provides a guideline for the determination of WQI, which involve monitoring of six parameters (pH, DO, BOD, COD, AN and TSS). A study of Lake Chini in May 2005 provided the following results.

Temp (°C)	DO ($mg\ L^{-1}$)	pH	BOD ($mg\ L^{-1}$)	COD ($mg\ L^{-1}$)	AN ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)
31.15	6.54	6.61	1.89	22.76	0.117	6.87

   Calculate the WQI value for Lake Chini and comment on the pollution status condition of the lake.

   (10 marks)

   b) The phosphate content of lake Chini in May 2005 was 0.083 $mg\ L^{-1}$. Discuss the implication of having the total P content of the lake increased to greater than 0.5 $mg\ L^{-1}$ due to a sudden pollution of the lake.

   (10 marks)

3. a) Use the pE-pH diagram below and answer the following questions.

i) What form of iron dominates in a methane producing environment at pH 6.5?

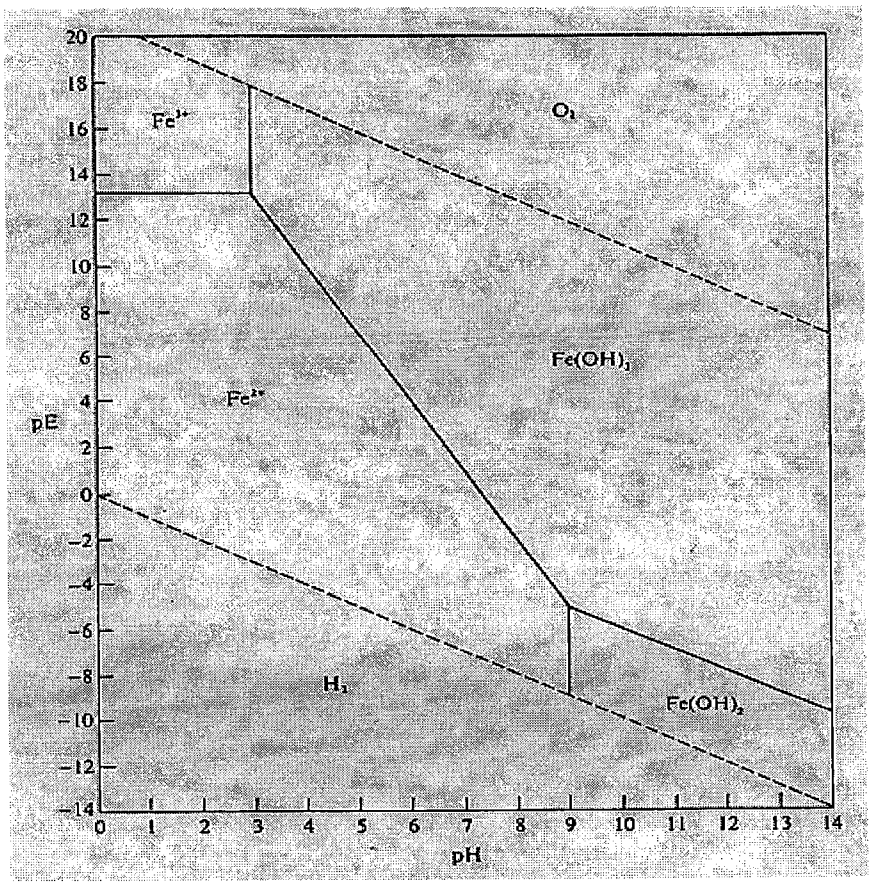
ii) What form of iron dominates in oxic waters at pH 7.0?

iii) At pH 4.0 and pE 11.6, what is the concentration of Fe^{+2} in equilibrium with $Fe(OH)_3$? Use the following information to aid your calculation.

$$Fe(OH)_3\,(s) + 3H^+ \longrightarrow Fe^{+3} + 3H_2O \qquad Ksp = 9.1x10^{3}$$

$$Fe^{+3} + e^- \longrightarrow Fe^{+2} \qquad pE° = 13.2$$

(9 marks)



b) One of the impact of chelating agent or ligands in the aquatic environment is to increase the solubility and mobility of heavy metals. This problem is illustrated for example by the increased dissolution of $Fe(OH)_3$ (s).
If a solution containing 30 mg L^{-1} NaNTA (sodium nitrilotriacetic acid, (MW=257) is equilibrated with Fe $(OH)_3$ and is then measured to have a pH of 6.0, what is the equilibrium ratio of $[Fe(NTA)]/[NTA^{2-}]$.

$Fe(OH)_3(s) + 3H^+ \longrightarrow Fe^{3+} + 3H_2O$ $\quad pK_{sp} = -3.96$

$Fe^{=3} + NTA^{-3} \rightleftharpoons Fe(NTA)$ $\quad pK_f = -17.9$

$HNTA^{-2} \rightleftharpoons NTA^{-3} + H^+$ $\quad pK_a = 10.28$

(6 marks)

c) Explain briefly why in the sampling of water samples for metal analysis, glass bottles must not be used and the water samples need to be preserved by adding acid nitric to pH 2.

(5 marks)

4. a) Differentiate between the terms of chemical oxygen demand (COD) and biochemical oxygen demand (BOD). Estimate the COD value of an aqueous solution of 0.340 g L^{-1} potassium phthalate ($C_5H_5O_4K$).

(8 marks)

c) A BOD analysis has been conducted on a wastewater from a factory. For this analysis, 5 mL of this wastewater was each placed in several BOD bottles and diluted to 300 mL. Results from the test are listed in the table below:

Day	DO (mg/L)
0	8.4
1	8.4
2	8.4
3	5.4
4	4.6
5	3.4
6	2.4
7	1.4
8	0.4
9	0.4

i) What is the value of BOD_5 for this wastewater?

ii) Calculate the value of ultimate BOD.

iii) Explain what had happened on the first two days of incubation.

iv) Why are the DO values for the eight and ninth days unacceptable?

(12 marks)

Section B

5. a) Explain briefly how a commercially available dissolved oxygen meter works. What would happen to dissolved oxygen (DO) of the water if its temperature and salinity rises.

(8 marks)

b) The ultimate BOD of a river just below a sewage outfall is 50.0 mg L^{-1} and the DO is at the saturation value of 10.0 mg L^{-1}. The deoxygenation rate coefficient (base e) k_d is 0.30 day^{-1} and the reaeration rate coefficient (base e) k_r is 0.90 day^{-1}. The river is flowing at the speed of 48.0 km per day. The only source of BOD in this river is the single sewage outfall.

i) Find the critical distance downstream at which DO is minimum.

ii) Find the minimum DO.

iii) If a wastewater treatment plant is to be built, what fraction of the BOD would have to be removed from the sewage to assure a minimum of 5.0 mg L^{-1} everywhere downstream?

(12 marks)

6. a) There are two types of pollutants produced from burning processes namely NO and SO_2.

i) Explain how the transformation of SO_2 to H_2SO_4 occurs in our atmosphere that leads to the formation of acid rain.

ii) Explain how NO is formed and its role as the source of ozone production within the troposphere, which is the main pollutant in smog problem in several main cities.

iii) Explain the dangerous effects of smog to the environment and human health.

(12 marks)

b) Determine the centerline, ground-level concentration of SO_2 1 km and 5 km downwind from a 1000 megawatt power plant burning 10000 tons of 1% sulfur coal per day. The effective stack height is 250 m on a clear, sunny day. The wind recorded on the same day was 3 m sec^{-1} at 10 m above the ground. The dispersion coefficients σ at these distances are given in the following table:

σ_x (km)	σ_y (m)	σ_z (m)
1	140	125
5	540	500

(8 marks)

7. a) Explain the meaning of a stable atmosphere and its impact on air pollution. For the case below, determine whether the temperature profile is unstable, neutral, or stable.
Initial temperature = 127 °C, final temperature = -68 °C.
Initial height = 211 m, final height = 20000 m

(6 marks)

c) Determine the plume rise at a distance of 500 m downward from a stack (40 m high) if the buoyancy flux from the source is 50 m^4 sec^{-3} and the wind velocity is 5 m sec^{-1}.

(6 marks)

c) The traffic on the highway can be considered a line source. The north-south highway traffic density along a certain stretch is 6,000 vehicles per hour with an average speed of 50 km h^{-1}. The average hydrocarbon emission rate for each vehicle can be taken as 0.03 g s^{-1}. Assume it is 2:30 p.m. on a bright, sunny day and the wind is blowing perpendicular to a portion of the highway at 6 m s^{-1}. Calculate the total hydrocarbon concentration at a point 500 m downwind.

(8 marks)

APPENDIX

1. Dilution table for BOD analysis

Direct Measurment		Premixing (Volume of Wastewater to total volume)	
Wastewater (mL)	**BOD range (mg L^{-1})**	**Percent Mixing**	**BOD range (mg L^{-1})**
0.20	3000 – 10,500	0.10	2000 – 7000
0.50	1200 – 4200	0.20	1000 – 3500
1.0	600 – 2100	0.50	400 – 1400
2.0	300 – 1050	1.0	200 – 700
5.0	120 – 420	2.0	100 – 350
10.0	6 – 210	5.0	40 – 140
20.0	30 – 105	10.0	20- 70
50.0	12 – 42	20.0	10 – 35
100	6 – 21	50.0	4 – 14

2. A table for saturated DO values for water of different temperatured

Temp (°C)	DO (mg L^{-1})
18	9.5
19	9.4
20	9.2
21	9.0
22	8.8
23	8.7
24	8.5
25	8.4
26	8.2
27	8.1
28	7.9
29	7.8
30	7.6

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$$\text{Log } r = \log(L_o K) - K_{10} t$$

$$L_t = L_o e^{-kt}$$

$$D_t = \frac{K_1 L_o}{K_2 - K_1}\left(e^{-K_1 t} - e^{-K_2 t}\right) + D_0 e^{-K_2 t}$$

$$t_c = \left[\frac{1}{K_2 - K_1}\right] \text{In}\left[\frac{K_2}{K_1}\left(1 - D_o \frac{K_2 - K_1}{L_o K_1}\right)\right]$$

$$C = \frac{C_1 \, x \, Q_1 + C_2 \, x \, Q_2}{Q_1 + Q_2}$$

$$K_2 = 3.9 \frac{\nu^{1/2}}{H^{3/2}}$$

$$K_T = K_{20} \text{ x } 1.047^{T-20}$$

$$K_T = K_{20} \text{ x } 1.022^{T-20}$$

$$BOD = \frac{(D_1 - D_2)}{P}$$

$$BOD = \frac{(D_1 - D_2) - (B_1 - B_2) f}{P}$$

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{2\sigma_y}\right)^2\right]\left[\exp -\frac{1}{2}\left(\frac{(Z-H)}{\sigma_z}\right)^2 + \exp\ -\frac{1}{2}\left(\frac{(Z-H)}{\sigma_z}\right)^2\right]$$

$$C_{maks} = \frac{0.1171Q}{\mu \sigma_y \sigma_z}$$

$$\Delta h_{max} = 1.6F^{1/3}(3.5x^*)^{2/3} u^{-1}$$

$$Y^* = 34F^{2/5}$$

$$F = gVR^2(T - T_A / T)$$

$$K = 2.61 \frac{B}{A}$$

$$L_0 = \frac{1}{2.3kA^3}$$

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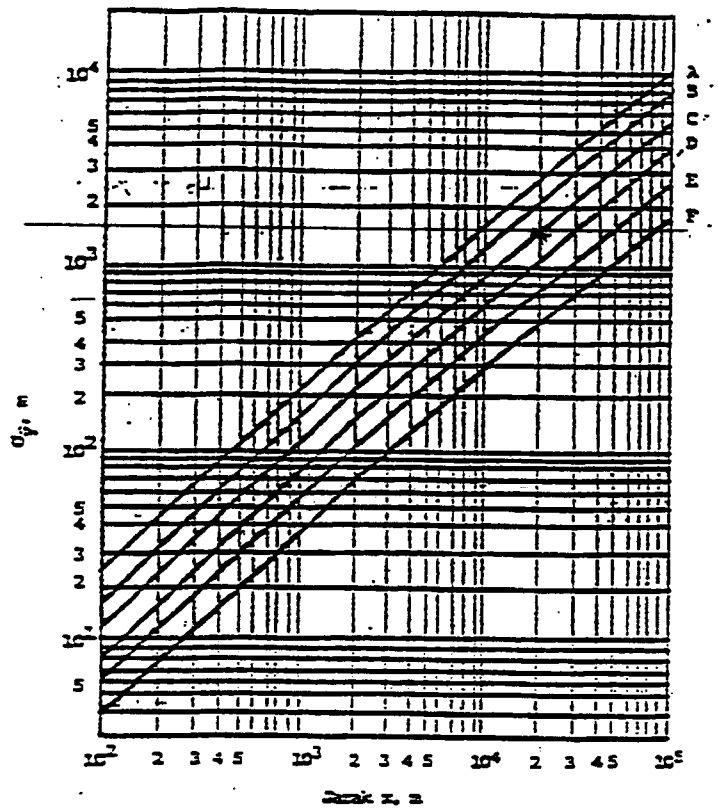
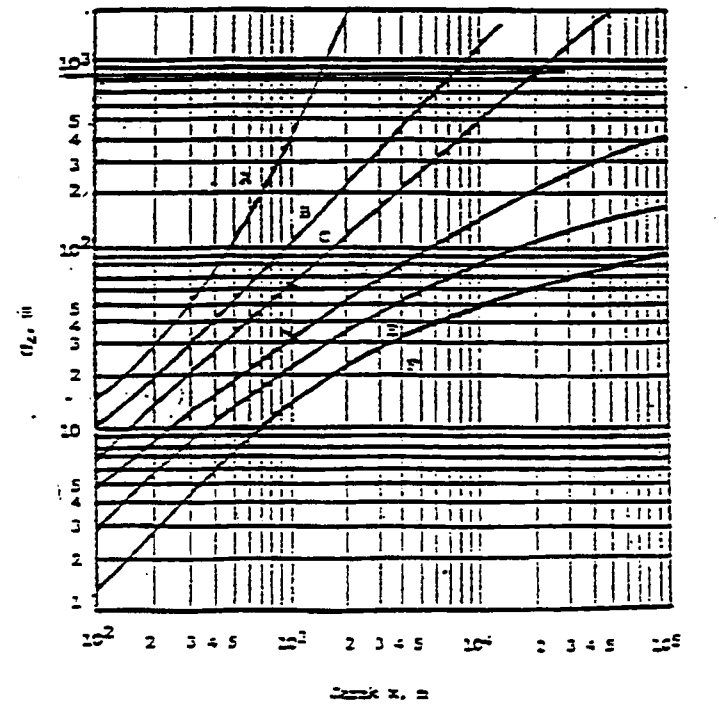
Plots Pasquill - Gifford





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A table of values for σ_Z coefficients.

Atmospheric stability classes	Distance downwind (meter) $100 < x \leq 500$		Distance downwind (meter) $500 < x \leq 5000$		Distance downwind (meter) $5000 < x$	
	a	b	a	b	a	b
A = 1	.0383	.1281	.0002539	2.089	.0002539	2.089
B = 2	.1393	.9467	.04936	1.114	.04936	1.114
C = 3	.1120	.9100	.1014	.926	.1154	.9109
DD = 4	.0856	.8650	.2591	.6869	.7368	.5642
DN = 5	.0818	.8155	.2527	.6341	1.297	.4421
E = 6	.1094	.7657	.2452	.6358	.9204	.4805
F = 7	.05645	.8050	.1930	.6072	1.505	.3662

A table for values of σ_Y coefficients.

Atmospheric stability classes	Distance downwind (meter) $x < 10{,}000$		Distance downwind (meter) $x \geq 10{,}000$	
	a	b	c	d
A = 1	.495	.873	.606	.851
B = 2	.310	.897	.523	.840
C = 3	.197	.908	.285	.867
DD = 4	.122	.916	.193	.865
DN = 5	.122	.916	.193	.865
E = 6	.0934	.912	.141	.868
F = 7	.0625	.911	.0800	.884

Relative atomic mass (RAM)

H = 1; C = 12; N = 14; O = 16; P = 31

S= 32 and Fe = 55.8

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)
where;
SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

TERJEMAHAN

Arahan:-

Jawab **LIMA** soalan sahaja. Jawab **TIGA** soalan daripada bahagian A dan **DUA** soalan daripada bahagian B.

Jawab setiap soalan pada muka surat yang baru.

Anda boleh menjawab 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.

Bahagian A

1. a) Dua bahan pencemar organic A dan B telah dilepaskan secara tidak sengaja ke dalam sebuah laluan air. Bahan pencemar A diketahui mempunyai pekali sekatan oktanol-air (K_{ow}) dan pekali sekatan karbon organic tanah –air yang tinggi (K_{oc}). Bahan pencemar B adalah berlawanan kepada A dengan kedua-dua K_{ow} dan K_{oc}.

   i) Ramalkan ketentuan setiap bahan pencemar ini dalam persekitaran akuatik.

   iii) Analisis kandungan A dalam kerang telah dijalankan selepas beberapa pendedahan dengan memberikan nilai purata 15.06 $\mu g\ g^{-1}$. Dengan menganggap kadar depurasi (β) bagi A ialah 0.09 $hari^{-1}$, anggarkan masa yang diperlukan untuk depurasi A oleh kerang mencapai 5 $ug\ g^{-1}$.

   (12 markah)

   b) Terangkan dengan ringkas kenapa aktiviti antrapogenik seperti pengyahhutan dan aktiviti pertanian dianggap sebagai factor kearah peningkatan pencemaran air.

   (8 markah)

2. a) Indeks kualiti air (WQI) diperkenalkan untuk menunjukkan darjah pencemaran sesuatu badan air tanpa menyatakan kesemua nilai-nilai parameter kualiti air. Jabatan Alam Sekitar Malaysia (DOE) memberikan satu gratis panduan untuk penetuan WQI yang melibatkan pemmonitoran enam parameters (pH, DO, BOD, COD, AN and TSS). Satu kajian keatas tasik Chini dalam bulan Mei 2005 memberikan hasil berikut.

Suhu (°C)	DO ($mg\ L^{-1}$)	pH	BOD ($mg\ L^{-1}$)	COD ($mg\ L^{-1}$)	AN ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)
31.15	6.54	6.61	1.89	22.76	0.117	6.87

   Berikan nilai WQI untuk tasik Chini bagi bulan Mei 2005 dan komen tentang keadaan pencemaran tasik tersebut.

   (10 markah)

   b) Kandungan fosfat dalam tasik Chini pada bulan Mei 2005 ialah 0.083 mgL^{-1}. bincangkan implikasi kandungan fosfat yang meningkat melebihi 0.5 $mg\ L^{-1}$ sekiranya berlaku pencemaran mendadak ke atas tasik tersebut.

   (10 markah)

3. a) Guna gambar rajah pE-pH di bawah dan jawab soalan-soalan berikut.

i) Apakah jenis besi yang anda ramalkan mendominasi dalamm persekitaran penjanaan metana pada pH 6.5?

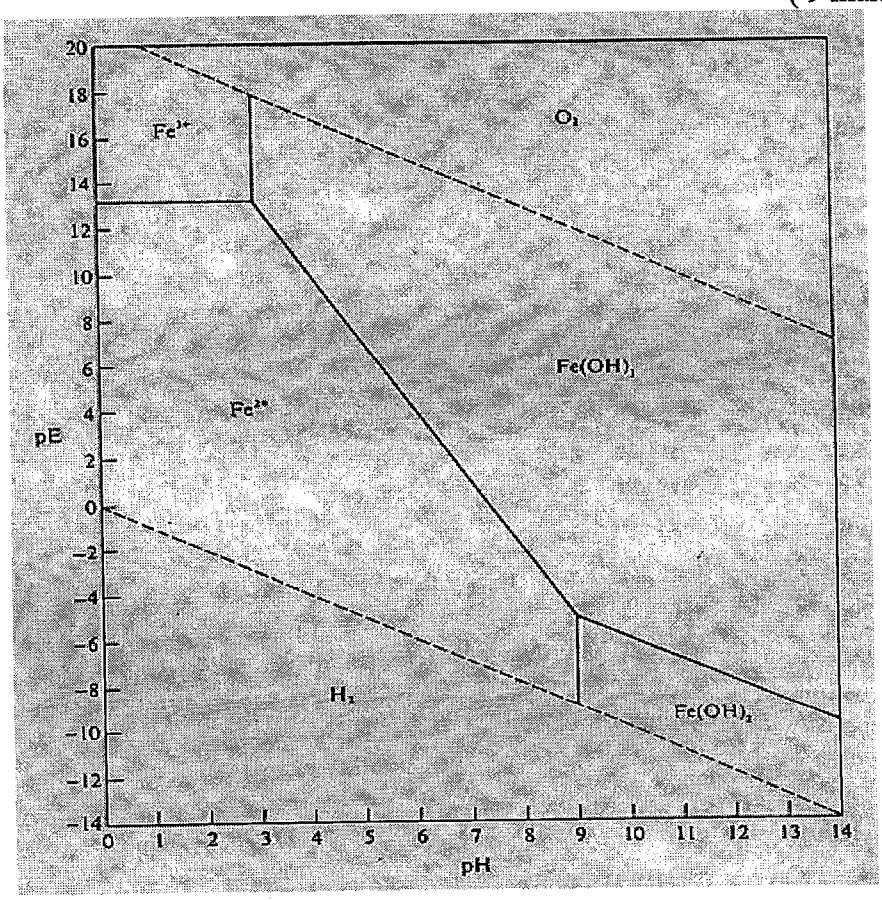
ii) Apakah jenis besi yang anda ramalkan mendominasi dalam air oksik pada pH 7.0?

iii) Pada pH 4.0 dan pE 11.6, apakah nilai kepekatan Fe^{+2} yang berkeseimbangan dengan $Fe(OH)_3$? Guna maklumat berikut untuk membantu anda dalam perkiraan.

$$Fe(OH)_3\ (s) + 3H^+ \longrightarrow Fe^{+3} + 3H_2O \qquad Ksp = 9.1x10^{3}$$

$$Fe^{+3} + e^- \longrightarrow Fe^{+2} \qquad p\square\square = 13.2$$

(9 markah)



b) Satu daripada kesan agen pengkelat atau ligan dalam persekitaran akuatik ialah meningkatkan keterlarutan dan kegerakan logam berat. Masaalah ini dinyatakan oleh contoh peningkatan keterlarutan $Fe(OH)_3$ (s). Sekiranya satu larutan yang mengandungi 30 mg L^{-1} NaNTA (MW=257) diseimbangkan dengan $Fe(OH)_3$ dan nilai pH yang disukat kemudiannya ialah 6.0, apakah nisbah keseimbangan $[Fe(NTA)]/[NTA^{2-}]$?

$Fe(OH)_3(s) + 3H^+ \longrightarrow Fe^{3+} + 3H_2O$ $\quad pK_{sp} = -3.96$

$Fe^{=3} + NTA^{-3} \rightleftharpoons Fe(NTA)$ $\quad pK_f = -17.9$

$HNTA^{-2} \rightleftharpoons NTA^{-3} + H^+$ $\quad pK_a = 10.28$

(6 markah)

c) Terangkan dengan ringkas kenapa dalam persampelan air untuk analisis logam, botol kaca perlu digunakan dan sample air perlu diawetkan dengan memasukkan asid nitric untuk menjadi pH 2.

(5 markah)

4. a) Bezakan diantara sebutan tuntutan oksigen kimia (COD) dan tuntutan oksigen biokimia (BOD). Anggarkan nilai COD suatu larutan akues of 0.340 g L^{-1} kalium ftalat ($C_5H_5O_4K$).

(8 markah)

b) Satu analisis BOD telah dijalankan ke atas satu air buangan daripada sebuah kilang. Untuk analisis ini, 5 mL air buangan ini diletakkan dalam beberapa botol BOD dan dicairkan kepada 300 mL. hasil daripada ujian ini disenaraikan di dalam jadula di bawah.

Hari	DO (mg/L)
0	8.4
1	8.4
2	8.4
3	5.4
4	4.6
5	3.4
6	2.4
7	1.4
8	0.4
9	0.4

i) Apakah nilai BOD_5 untuk air buangan ini?

ii) Kira nilai BOD ultimat.

iii) Jelaskan apa yang berlaku pada dua hari pertama pengeraman.

iv) Kenapakah nilai DO untuk hari kelapan dan kesembilan tidak dapat diterima?

(12 markah)

Bahagian B

5. a) Terangkan dengan ringkas mekanisme pengukuran meter oksigen komersial. Apakah yang akan berlaku terhadap nilai oksigen terlarut (DO) sekiranya suhu dan saliniti nya meningkat.

(8 markah)

b) BOD ultimat sebuah sungai hanya sebelum kemasukkan air buangan ialah 50.0 mg L^{-1}. Pekali kadar penyahoksigenan (asas e) k_d ialah 0.30 $hari^{-1}$ dan pekali kadar pengudaraan (asas e) k_r ialah 0.90 $hari^{-1}$. Sungai ini mengalir pada kelajuan of 48.0 km per hari. Sumber BOD sungai ini hanyalah air buangan tersebut.

i) Cari jarak kritis di hilir sungai di mana DO adalah minimum.

ii) Cari nilai Do minimum.

iii) Sekiranya sebuah loji perawatan airbuangan ingin dibina, berapakah peratus BOD perlu dilupuskan daripada air buangan tersebut bagi mempastikan nilai minimum 5.0 mgL^{-1} tercapai dihilir sungai?

(12 markah)

6. a) Terdapat dua jenis bahan pencemar yang dihasilkan daripada proses pembakaran iaitu NO and SO_2.

i) Terangkan bagaimana transformasi SO_2 kepada H_2SO_4 berlaku dalam atmosfera yang membawa kepada pembentukan hujan asid.

ii) Terangkan bagaimana NO terhasil dan perannya sebagai sumber penjanaan ozon dalam troposfera dimana ia adalah bahan pencmear utama dalam masalah asbut dibeberapa buah bandar.

(12 markah)

b) Tentukan kepekatan SO_2 pada garis pusat, paras bumi pada 1 km dan 5 km mengikut arah angin darip[ada loji kuasa tenaga 1000 megawat yang membakar 10000 ton arang batu mengandungi 1% sulfur setiap hari. Ketinggian berkesan cerobong ialah 250 m pada hari yang panas dan cerah. Tiupan angin yang dirakamkan pada hari yang sama ialah 3m $saat^{-1}$ pada 10 m di atas bumi. Pekali penyerakan pada jarak-jarak dim atas ialah :

σ_x (km)	σ_y (m)	σ_z (m)
1	140	125
5	540	500

(8 markah)

7. a) Terangkan maksud atmosfera stabil dan kesannya ke atas pencemaran udara. Untuk kes dibawah, tentukan sama ada profil suhu adalah tak stabil, neutral atau pun stabil.

Suhu awal = 127 °C, suhu akhir = -68 °C. Ketinggian awal Initial = 211 m, ketinggian akhir = 20000 m

(6 markah)

b) Tentukan kenaikan plum pada jarak 500 m daripada satu cerobong (40 m tinggi) sekiranya fluks keapongan daripada punca ialah 50 m^4/sec^3 dan kelajuan angina ialah 5 m/sec.

(6 markah)

c) Trafik dijalan raya boleh dianggap sebagai satu sumber garis. Ketumpatan trafik pada satu kawasan lebuh raya utara selatan ialah 6,000 kenderaan per jam dengan kelaju7an purata 50 batu sejam. Kadar pancaran purata hidrokarbon bagi setiap kereta ialah 0.03 gs^{-1}. Anggap suasana adalah 2.30 petang pada hari yang cerah dan panas dan angin bertiup menegak kepada lebuh raya apda kelajuan 6 ms^{-1}. Kira kepekatan total hidrokarbon pada satu titik 500 m mengikut arah angin.

(8 markah)

LAMPIRAN

1. Jadual Pencairan Analisis BOD

Melalui Penyukatan Terus		Melalui Pencampuran [Isipadu Air Buangan] [Isipadu Total Campuran]	
Air Buangan (mL)	**Julat BOD (mg L^{-1})**	**Peratus Campuran**	**Julat BOD (mg L^{-1})**
0.20	3000 – 10,500	0.10	2000 – 7000
0.50	1200 – 4200	0.20	1000 – 3500
1.0	600 – 2100	0.50	400 – 1400
2.0	300 – 1050	1.0	200 – 700
5.0	120 – 420	2.0	100 – 350
10.0	6 – 210	5.0	40 – 140
20.0	30 – 105	10.0	20- 70
50.0	12 – 42	20.0	10 – 35
100	6 – 21	50.0	4 – 14

2. Jadual Nilai DO Tepu Bagi Air Pada Suhu Yang Berbeza.

Suhu (°C)	DO (mg L^{-1})
18	9.5
19	9.4
20	9.2
21	9.0
22	8.8
23	8.7
24	8.5
25	8.4
26	8.2
27	8.1
28	7.9
29	7.8
30	7.6

...19/-

$$\text{Log r} = \log (L_o K) - K_{10} t$$

$$L_t = L_o e^{-kt}$$

$$D_t = \frac{K_1 L_o}{K_2 - K_1}\left(e^{-K_1 t} - e^{-K_2 t}\right) + D_0 e^{-K_2 t}$$

$$t_c = \left[\frac{1}{K_2 - K_1}\right] \text{In}\left[\frac{K_2}{K_1}\left(1 - D_o \frac{K_2 - K_1}{L_o K_1}\right)\right]$$

$$C = \frac{C_1 \text{ x } Q_1 + C_2 \text{ x } Q_2}{Q_1 + Q_2}$$

$$K_2 = 3.9 \frac{v^{1/2}}{H^{3/2}}$$

$$K_T = K_{20} \text{ x } 1.047^{T-20}$$

$$K_T = K_{20} \text{ x } 1.022^{T-20}$$

$$BOD = \frac{(D_1 - D_2)}{P}$$

$$BOD = \frac{(D_1 - D_2) - (B_1 - B_2) f}{P}$$

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{2\sigma_y}\right)^2\right]\left[\exp -\frac{1}{2}\left(\frac{(Z-H)}{\sigma_z}\right)^2 + \exp\ -\frac{1}{2}\left(\frac{(Z-H)}{\sigma_z}\right)^2\right]$$

$$C_{maks} = \frac{0.1171 Q}{\mu \sigma_y \sigma_z}$$

$$\Delta h_{max} = 1.6 F^{1/3} (3.5 x^*)^{2/3} u^{-1}$$

$$Y^* = 34 F^{2/5}$$

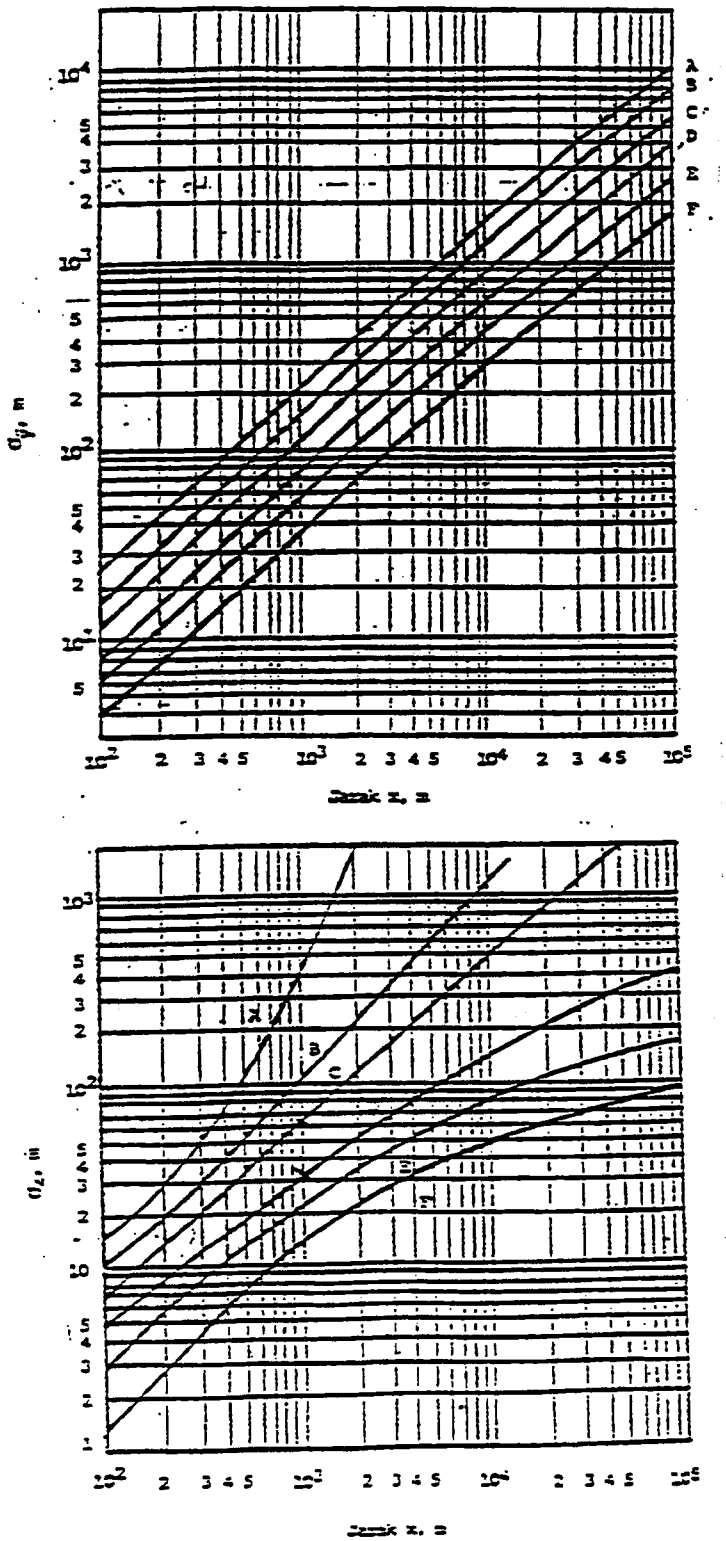
$$F = gVR^2 (T - T_A / T)$$

$$K = 2.61 \frac{B}{A}$$

$$L_0 = \frac{1}{2.3 k A^3}$$

...20/-

Keluk Passquill-Gifford



...21/-

Jadual pekali untuk nilai σ_Z

Kelas Kestabilan Atmosfera	Jarak Dihilir angin (meter) $100 < x \leq 500$		Jarak Dihilir angin (meter) $500 < x \leq 5000$		Jarak Dihilir angina (meter) $5000 < x$	
	a	b	a	b	a	b
A = 1	.0383	.1281	.0002539	2.089	.0002539	2.089
B = 2	.1393	.9467	.04936	1.114	.04936	1.114
C = 3	.1120	.9100	.1014	.926	.1154	.9109
DD = 4	.0856	.8650	.2591	.6869	.7368	.5642
DN = 5	.0818	.8155	.2527	.6341	1.297	.4421
E = 6	.1094	.7657	.2452	.6358	.9204	.4805
F = 7	.05645	.8050	.1930	.6072	1.505	.3662

Jadual pekali untuk nilai σ_Y

Kelas Kestabilan Atmosfera	Jarak Dihilir angin (meter) $x < 10,000$		Jarak Dihilir angin (meter) $x \geq 10,000$	
	a	b	c	d
A = 1	.495	.873	.606	.851
B = 2	.310	.897	.523	.840
C = 3	.197	.908	.285	.867
DD = 4	.122	.916	.193	.865
DN = 5	.122	.916	.193	.865
E = 6	.0934	.912	.141	.868
F = 7	.0625	.911	.0800	.884

Jisim Atom Relatif (JAR)

H = 1; C = 12; N = 14; O = 16; P = 31

S= 32 dan Fe = 55.8

...22/-

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)
where;
SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

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