UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

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

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of TWENTY NINE 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.

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

Section A

1. (a) Two organic pollutants lindane (γ-hexachlorocyclohexane) and tetrachloroethylene had accidentally been discharged into a waterway. Lindane is known to have high octanol-water partition coefficient (K_{ow}) and soil organic carbon-water partition coefficient ($K_{oc)}$ and vapor pressure of 0.0043 Pa at 20°C. Tetrachloroethylene however is the opposite of lindane with low K_{ow} and low K_{oc} and a vapor pressure of $8.0x10^3$ Pa.

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

   (ii) Analysis of the content of lindane in the cockle has been conducted after a few days of exposure giving an average value of 25.06 ug g^{-1}. Assuming that the depuration rate constant (β) for lindane is 0.09 day^{-1}, estimate the time needed for the depuration of lindane by cockles to reach 5 ug g^{-1}.

   (12 marks)

   (b) There are quite a number of substances that have been discharged into the environment. In the assessment of their environmental impact, several factors and characteristics of such substances need to be evaluated. Briefly describe these factors and characteristics that need to be taken into account in such assessment.

   (8 marks)

2. (a) Two rivers, A and B have been analyzed for their respective water quality parameters and the results are given in the following table. Determine which one would be a better source of water supply based on their respected water quality index (WQI).

Rivers	Temp (°C)	DO (mg L^{-1})	pH	BOD (mg L^{-1})	COD (mg L^{-1})	AN (mg L^{-1})	TSS (mg L^{-1})
A	31.15	6.54	6.61	1.89	22.76	0.117	6.87
B	31.0	6.3	7.0	3.5	25.8	0.211	6.57

(8 marks)

   (b) A lake contaminated with phosphate for quite a long time is recommended to dredge out its sediment instead of only controlling the entry of phosphate into its water body. Explain why such an expensive operation is necessary in saving the lake from extinction. Provide several necessary aquatic chemical reactions of phosphate in order to strengthen your argument.

   (12 marks)

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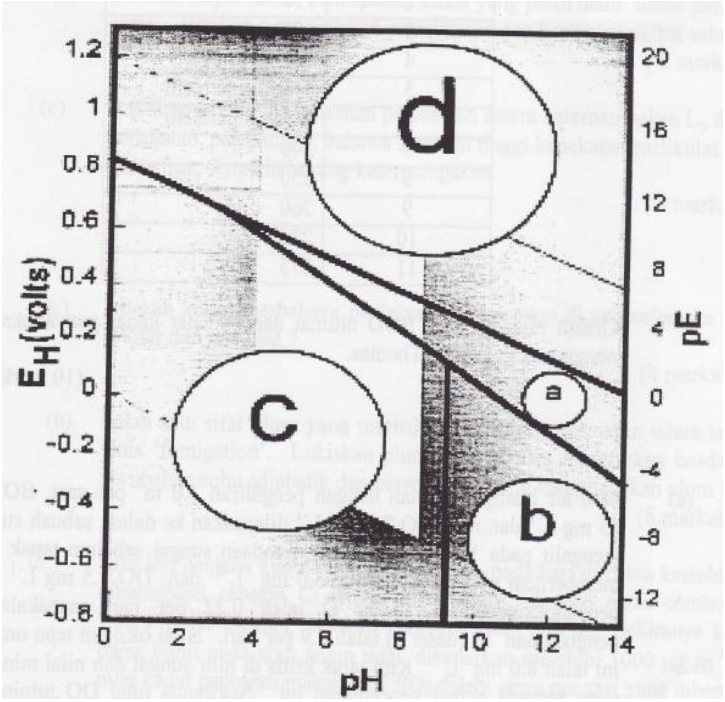
3. (a) The figure below is a pE-pH diagram of a nitrogen system. The species involved are NH_3, NH_4^+, NO_2^- and NO_3^-.



Based on your understanding of the characteristics of each species and also the concept of pE-pH diagram, provide the main nitrogen species for the labeled regions of a, b, c and d in the figure above. Justify your answer.

(8 marks)

(b) The information provided below is for the iron system in the present of carbonate species in the aquatic environment.

Maximum concentration of Fe^{2+} = 10^{-3} M
$[HCO_3^-]$ = 1.0 x 10^{-2} M
$[CO_3^{2-}]$ = 1.0 x 10^{-2} M
Atmospheric pressure = 1.00 atm

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

$Fe(OH)_2 + 2H^+ \quad Fe^{2+} + 2H_2O \quad K_{eq} = 8 \times 10^{12}$

$FeCO_3 \quad Fe^{2+} + CO_3^{2-} \quad K_{eq} = 3.5 \times 10^{-11}$

$Fe(OH)_3 + 3H^+ \quad Fe^{3+} + 3H_2O \quad K_{eq} = 9.1 \times 10^{3}$

Prove that the boundary line for the $Fe(OH)_3$-$Fe(CO_3)$ in the pE-pH diagram follows the following equation:

$$pE = 15.3 - 2pH$$

(8 marks)

(c) Explain briefly why in the sampling of water samples for metal analysis, glass bottles must be used and the water samples need to be preserved by adding nitric acid to pH 2.

(4 marks)

4. (a) Differentiate between the terms of chemical oxygen demand (COD) and total organic carbon (TOC). Estimate the COD value of an aqueous solution of 0.520 g/L glucose ($C_6H_{12}O_6$).

(8 marks)

(b) BOD analyses of a domestic wastewater over a period of 11 days are given in the table below.

Day	**BOD (mg L^{-1})**
0	0
1	57
2	110
3	155
4	183
5	Not taken
6	Not taken
7	240
8	250
9	260
10	270
11	275

(i) What is the value of BOD_5 for this wastewater?
(ii) Calculate the value of the ultimate BOD.
(iii) Calculate the deoxygenation constant, k using the Thomas method for this wastewater.

(12 marks)

Section B

5. (a) A treated wastewater with a flow of 1.0 $m^3 s^{-1}$, ultimate BOD of 45 mg L^{-1} and dissoved oxygen (DO) of 2.0 mg L^{-1} was discharged into a river with a flow of 10.0 $m^3 s^{-1}$. The ultimate BOD of the river before the discharge point was 3.0 mg L^{-1} and its DO was 7.5 mg L^{-1}. The deoxygenation coefficient, k_1 (based e) was 0.22 day^{-1} while the reaeration rate coefficient , k_2 (based e) was 0.9 day^{-1}. The saturated DO value for the river was 8.0 mg L^{-1}.

(i) Calculate the critical distance downstream and the minimum DO.
(ii) If the DO level need to be revived by 10 %, what would be the value of the ultimate BOD of the wastewater that must be adhered to before it is allowed to be discharged.

(12 marks)

(b) Primary air quality standard for sulfur dioxide (SO_2) for yearly average is 80 µg m^{-3}. What is the equivalent concentration in ppm at 25 °C ?

(4 marks)

(c) Provides the mechanism for the ozone depletion due to the presence of freon, CF_2Cl_2, in the stratosphere.

(4 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) A power plant emits SO_2 on a day that has an air stability of class C with the wind speed at the stack level to be 7 m s^{-1}. The effective stack height is 282 m. If the SO_2 concentration at ground level in the direction of the wind is limited to not more than 1000 µg m^{-3}, what is the maximum rate of emission of SO_2 that is allowed to be emitted by the plant in term of g s^{-1}?

(8 marks)

7. (a) (i) For each case given in the table below, determine wether the environmental temperature profile is instable, neutral or stable.

Cases	Initial Temp ° C	Final Temp °C	Initial altitude, m	Final altitude, m
A	-57.62	-68	211	2000
B	8.73	-35	400	1221
C	-14.7	-30	1000	4000

(ii) Define the meaning of the atmospheric inversion. How does atmospheric inversion worsen the effect of air pollution of a given area.

(8 marks)

(b) Determine the plume rise at a distance of 600 m downward from a stack (40 m high) if the buoyancy flux from the source is 40 $m^4 s^{-3}$ and the wind velocity is 5 m s^{-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 9000 vehicles per hour with an average speed of 60 km h^{-1}. The average hydrocarbon emission rate for each vehicle can be taken as 0.04 g s^{-1}. Assume that it is 1:30 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.

(6 marks)

List of abbreviations

Abbreviations	Expanded Names
AN	Ammoniacal Nitrogen
BOD	BiochemicaL Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
TDS	Total Dissolved Solid
TOC	Total organic carbon
TSS	Total Suspended solid

APPENDIX

1. Dilution table for BOD analysis

Direct Measurement		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

Log r = log (L_oK) – $K_{10}t$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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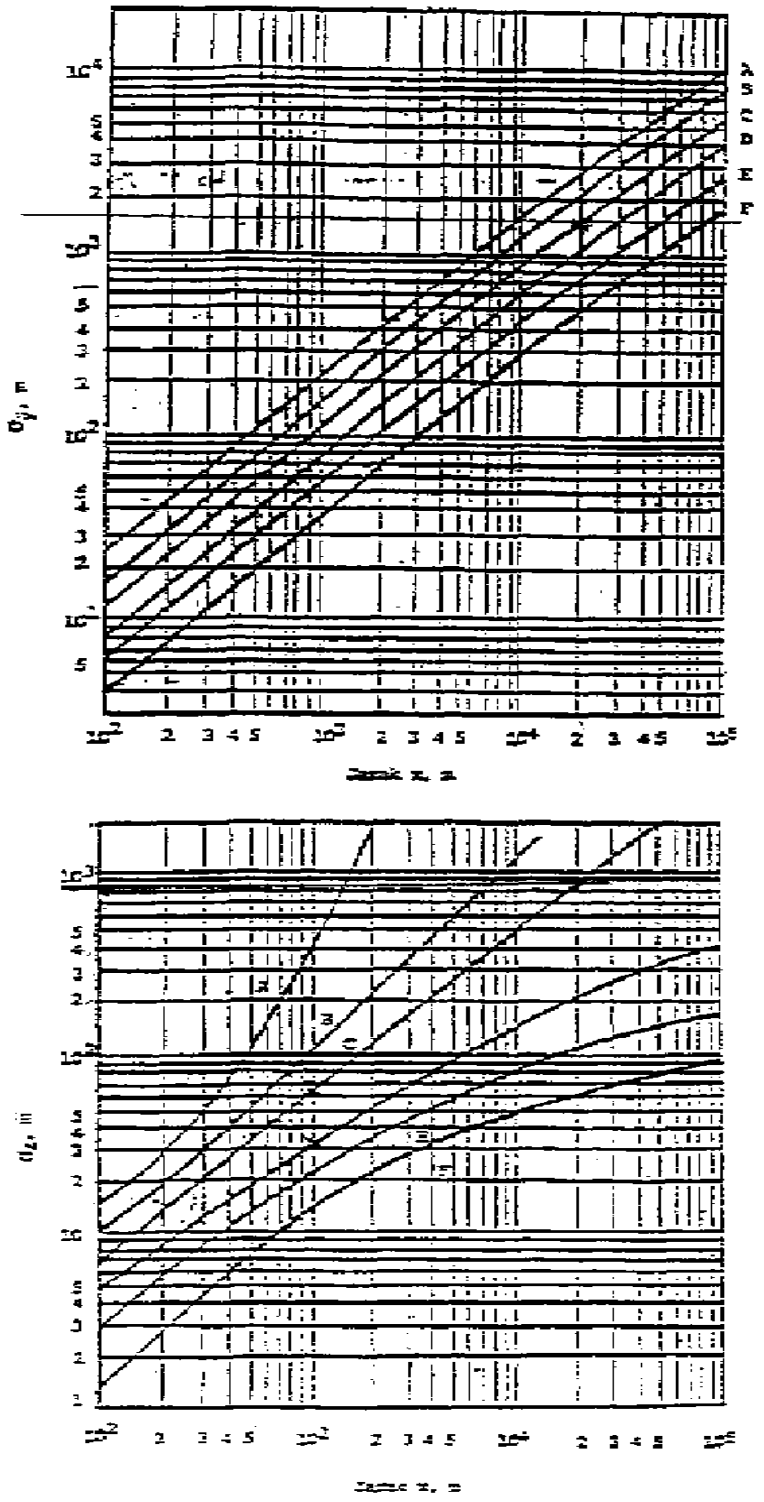
PLOTS PASQUILL –GIFFORD



A table of values for σ_Z coefficients.

Atmospheric stability classes	Distance downwind (meter) 100 < x ≤ 500		Distance downwind (meter) 500 < x ≤ 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 ≥ 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 FORMULA AND CALCULATION

FORMULA

$$WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)$$

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

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Subindex for DO (in % saturation)	
$SIDO = 0$	for $x \leq 8$
$SIDO = 100$	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$
Subindex for BOD	
$SIBOD = 100.4 - 4.23x$	for $x \leq 5$
$SIBOD = 108 * \exp(-0.055x) - 0.1x$	for $x > 5$
Subindex for COD	
$SICOD = -1.33x + 99.1$	for $x \leq 20$
$SICOD = 103 * \exp(-0.0157x) - 0.04x$	for $x > 20$
Subindex for NH_3-N	
$SIAN = 100.5 - 105x$	for $x \leq 0.3$
$SIAN = 94 * \exp(-0.573x) - 5 * \lvert x - 2 \rvert$	for $0.3 < x < 4$
$SIAN = 0$	for $x \geq 4$
Subindex for SS	
$SISS = 97.5 * \exp(-0.00676x) + 0.05x$	for $x \leq 100$
$SISS = 71 * \exp(-0.0061x) - 0.015x$	for $100 < x < 1000$
$SISS = 0$	for $x \geq 1000$
Subindex for pH	
$SIpH = 17.2 - 17.2x + 5.02x^2$	for $x < 5.5$
$SIpH = -242 + 95.5x - 6.67x^2$	for $5.5 \leq x < 7$
$SIpH = -181 + 82.4x - 6.05x^2$	for $7 \leq x < 8.75$
$SIpH = 536 - 77.0x + 2.76x^2$	for $x \geq 8.75$

	Stable Atmosphere	Neutral/Unstable Atmosphere
Buoyancy Dominated	$\Delta h(x) = 1.6F^{1/3} x^{2/3} U^{-1}$ (6) or $\Delta h_{MAX} = 2.6(F/Us)^{1/3}$ (7) where $s = 0.02g/T_A$ for E stability $s = 0.035g/T_A$ for F stability For sources located in Texas $s = 0.018g/T_A$ for E stability $s = 0.025g/T_A$ for F stability	$\Delta h(x) = 1.6F^{1/3} x^{2/3} U^{-1}$ (6) for $x < 3.5x^*$ or $\Delta h_{MAX} = 1.6F^{1/3}(3.5x^*)^{2/3} U^{-1}$ (8) for $x > 3.5x^*$ where $x^* = 14F^{5/8}$ if $F < 55$ $x^* = 34F^{2/5}$ if $F > 55$
Momentum Dominated	$\Delta h_{MAX} = 1.5(VR)^{2/3} U^{-1/3} s^{-1/6}$ (9) where s is defined as above	$\Delta h(x) = 3.78\left(\frac{V^2}{U(V+3U)}\right)^{2/3}\left(\frac{xR^2}{2}\right)^{1/3}$ (10) or $\Delta h_{MAX} = 3VD/U$ (11)

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

T = source temperature, °K

T_A = ambient temperature, °K

V = stack exit velocity, m/s

R = stack radius, m

D = stack diameter, m

x = downwind distance, m

U = wind speed at physical source height, m/s

g = acceleration due to gravity 9.8 m/s^2

Δh = plume rise, m

Δh_{MAX} = final plume rise, m

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Table 2. Stability Classification ("Procedures for Evaluation Air Quality Impact of New Stationary Sources", EPA)

Surface wind speed (m/s)	Daytime insolation			Nighttime	
	strong	moderate	slight	Thin overcast or > 4/8 low cloud cover	< 3/8 cloud cover
< 2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
> 6	C	D	D	D	D

Neutral class (D) is assumed for all overcast conditions during day or night.

Night is defined as the period from one hour before sunset to one hour after sunrise.

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.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Bahagian A

1. (a) Dua bahan pencemar organic, lindana (γ-heksaklorosikloheksana) dan tetrakloroetilina telah didiscaj secara tidak senagaja ke sebuah laluan air. Lindana diketahui mempunyai pekali sekatan oktanol-air (K_{ow}) dan pekali sekatan karbon organic tanah- air ($K_{oc)}$ yang tinggi serta tekanan wap 0.0043 Pa pada 20°C. Tetrakloroetilena pula mempunyai sifat berlawanan dengan lindana dimana nilai K_{ow} dan K_{oc} adalah rendah dan tekanan wap sebanyak $8.0x10^3$ Pa.

   (i) Ramalkan tentuan setiap bahan pencemar ini di dalam persekitaran akuatik.

   (ii) Analisis kandungan lindana dalam kerang telah dilakukan selepas beberapa hari pendedahan dengan memberikan nilai purata 25.06 ug g^{-1}. Dengan menganggap kadar pemalar depurasi (β) untuk lindana ialah 0.09 $hari^{-1}$, anggarkan masa yang diperlukan untuk depurasi terhadap lindana oleh kerang untuk mencapai nilai 5 ug g^{-1}.

   (12 markah)

   (b) Terdapat banyak bahan yang telah didiscaskan kedalam persekitaran. Dalam mentaksirkan kesannya terhadap persekitaran, beberapa faktor dan sifat keperibadian bahan-bahan tersebut perlu dinilai. Perikan secara ringkas faktor dan sifat keperibadian ini yang perlu diambil kira dalam penilaian tersebut.

   (8 markah)

2. (a) Dua sungai, A and B telah di analisis parameter kualiti air dan keputusannya diberikan di dalam jadual di bawah. Tentukan sungai manakah yang lebih baik dijadikan sebagai sumber bekalan air berdasarkan indeks kualiti air (WQI) masing-masing.

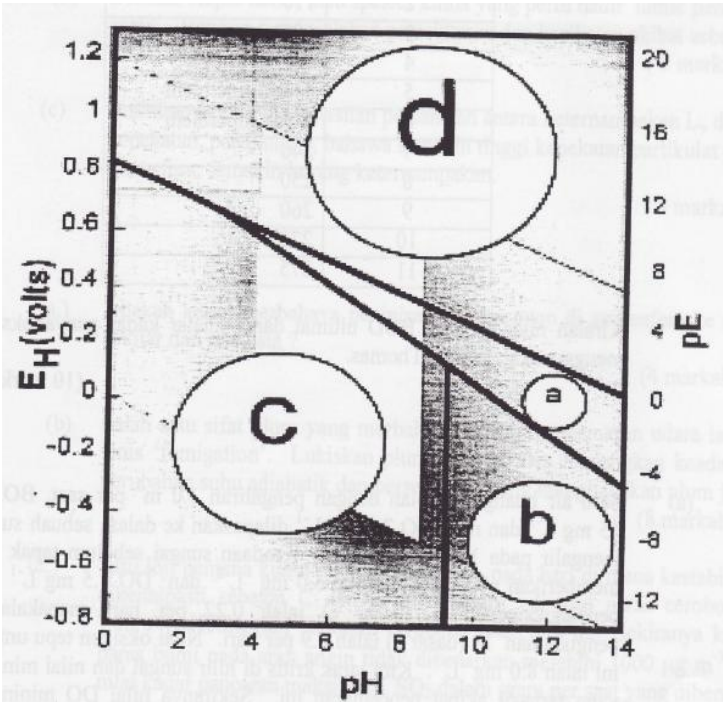
Sungai	Suhu (°C)	DO (mg L^{-1})	pH	BOD (mg L^{-1})	COD (mg L^{-1})	AN (mg L^{-1})	TSS (mg L^{-1})
A	31.15	6.54	6.61	1.89	22.76	0.117	6.87
B	31.0	6.3	7.0	3.5	25.8	0.211	6.57

(8 markah)

(b) Sebuah tasik telah dicemari fosfat untuk sekian lama dan telah dicadangkan untuk mengorek keluar endapan dan bukan sekadar mengawal kemasukan fosfat kedalam badan airnya. Jelaskan kenapa operasi semahal itu dianggap perlu demi menyelamatkan tasik tersebut daripada menjadi pupus.

(12 markah)

3. (a) Rajah di bawah ialah sebuah rajah pE-pH system nitrogen. Spesies yang terlibat ialah NH_3, NH_4^+, NO_2^- dan NO_3^-.



Berdasarkan kefahaman anda terhadap sifat-sifat setiap sesies dan juga konsep gambarajah pE-pH , berikan spesies utama nitrogen untuk setiap kawasan yang berlabel a, b, c dan d dalam rajah di atas. Justifikasikan jawapan anda.

(8 markah)

(b) Maklumat yang diberikan dibawah ialah untuk sistem besi dengan kehadiran karbonat dalam persekitaran akuatik.

Kepekatan maksimum $Fe^{2+} = 10^{-3}$ M
$[HCO_3^-] = 1.0 \times 10^{-2}$ M
$[CO_3^{2-}] = 1.0 \times 10^{-2}$ M
Tekanan atmosfera = 1.00 atm

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

$Fe(OH)_2 + 2H^+ \quad Fe^{2+} + 2H_2O \quad K_{eq} = 8 \times 10^{12}$

$FeCO_3 \quad Fe^{2+} + CO_3^{2-} \quad K_{eq} = 3.5 \times 10^{-11}$

$Fe(OH)_3 + 3H^+ \quad Fe^{3+} + 3H_2O \quad K_{eq} = 9.1 \times 10^{3}$

Buktikan bahawa sempadan untuk $Fe(OH)_3$-$Fe(CO_3)$ bagi gambarajah mematuhi persamaan :

$$pE = 15.3 - 2pH$$

(8 markah)

(c) Jelaskan dengan ringkas kenapa dalam persampelan air untuk analisis logam, botol kaca perlu digunakan dan sampel air perlu diawet dengan menambah asid nitrik sehingga kepada pH 2.

(4 markah)

4. (a) Bezakan di antara sebutan tuntutan oksigen kimia (COD) dan organik karbon total (TOC). Anggarkan nilai COD bagi satu larutan akueus 0.520 g L^{-1} glukosa ($C_6H_{12}O_6$).

(8 markah)

(b) Di bawah diberikan data BOD yang diperolehi daripada suatu sampel air buangan domestik meliputi jangka masa 11 hari.

Hari	**BOD (mg L^{-1})**
0	0
1	57
2	110
3	155
4	183
5	Tidak diambil
6	Tidak diambil
7	240
8	250
9	260
10	270
11	275

(i) Apakah nilai BOD_5 untuk air buangan ini ?

(ii) Kira nilai BOD ultimat.

(iii) Kira pemalar penyahoksigenan, k untuk air buangan ini menggunakan kaedah Thomas.

(12 markah)

Bahagian B

5. (a) Satu air buangan terolah dengan pengaliran 1.0 $m^3 s^{-1}$, BOD ultimat 45 mg L^{-1} dan nilai oksigen terlarut (DO) 2.0 mg L^{-1} dilepaskan ke dalam sebuah sungai yamg mengalir pada 10.0 $m^3 s^{-1}$. Nilai BOD ultimat sungai tersebut sebelum tapak pelepasan ialah 3.0 mg L^{-1} dan DO ialah 7.5 mg L^{-1}. Pemalar penyahoksigenan , k_1 (dasar e) adalah 0.22 $hari^{-1}$ manakala pemalar pengudaraan , k_2 (dasar e) adalah 0.9 $hari^{-1}$. Nilai DO tepu untuk sungai ini ialah 8.0 mg L^{-1}.

(i) Kira jarak kritis di hilir sungai dan nilai DO minimumnya.

(ii) Sekiranya nilai DO minimum ini ingin dipulihkan sebanyak 10 %, berapakah nilai BOD ultimat air buangan yang perlu dihadkan sebelum pelepasan?

(12 markah)

(b) Piawai primer kualiti udara bagi sulfur dioksida (SO_2) untuk purata tahunan ialah 80 µg m^{-3}. Apakah kepekatan setara dalam ppm pada 25 °C?

(4 markah)

(c) Berikan mekanisme pelupusan ozon oleh kehadiran Freon dalam stratosfera. Formula freon ialah CF_2Cl_2.

(4 markah)

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

(i) Jelaskan bagaimana bagaimana transformasi SO_2 kepada H_2SO_4 berlaku di dalam atmosfera kita yang membawa kepada penghasilan hujan asid.

(ii) Jelaskan bagaimana NO terbentuk dan peranannya sebagai sumber penghasilan ozon dalam trofosfera di mana ia adalah bahan pencemar utama dalam masalah asbut di beberapa bandar utama.

(iii) Jelaskan kesan-kesan bahaya asbut terhadap alam sekitar dan kesihatan manusia.

(12 markah)

(b) Sebuah loji penjana kuasa memancarkan SO_2 pada suatu hari yang mempunyai kestabilan udara kelas C dan kelajuan angin di atas paras cerobong pada 7 m s^{-1}. Ketinggian berkesan cerobong ialah 282 m. Sekiranya kepekatan paras bumi pada arah angin tidak dibenarkan melebihi 1000 µg m^{-3}, apakah nilai kadar pancaran maksimum SO_2 dalam g s^{-1} yang dibenarkan?

(8 markah)

7. (a) (i) Bagi setiap kes yang diberikan di dalam jadual di bawah, tentukan sama ada profil suhu persekitaran tak stabil, neutral atau stabil.

Cases	Initial Temp ° C	Final Temp °C	Initial altitude, m	Final altitude, m
A	-57.62	-68	211	2000
B	8.73	-35	400	1221
C	-14.7	-30	1000	4000

(ii) Berikan definasi sosangan atmosfera. Apakah kesannya ke atas pencemaran udara bagi sesuatu kawasan.

(8 markah)

(b) Tentukan kenaikan plum pada jarak 600 m ke arah bawah cerobong (40 m tinggi) sekiranya fluks keapungan daripada sumber ialah 40 m^4 s^{-3} dan kelajuan angin ialah 5 m s^{-1}.

(6 markah)

(c) Trafik di lebuh raya boleh dianggap sebagai satu sumber garis. Ketumpatan trafik bagi lebuh raya utara-selatan pada satu jaraj tertentu ialah 9000 kenderaan per jam dengan purata kelajuan 100 km j^{-1}. Kadar purata pancaran hidrokarbon bagi setiap kenderaan boleh lah dianggap sebanyak 0.04 g s^{-1}. Anggaplah pada jam 1:30 p.m. keadaan adalah cerah, matahari terik dan angin bertiup secara menegak kepada sebahagian lebuh raya dengan kelajuan 6 m s^{-1}. Kiralah kepekatan total hidrokarbon pada suatu tapak 500 m mengikut arah angin.

(6 markah)

Senarai Sebutan

Sebutan	Nama Terperinci
AN	Nitrogen Amonia
BOD	Tuntutan Oksigen Biokimia
COD	Tuntutan Oksigen Kimia
DO	Oksigen Terlarut
TDS	Pepejal Terlarut Total
TOC	Karbon Organik Total
TSS	Pepejal Terampai Total

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

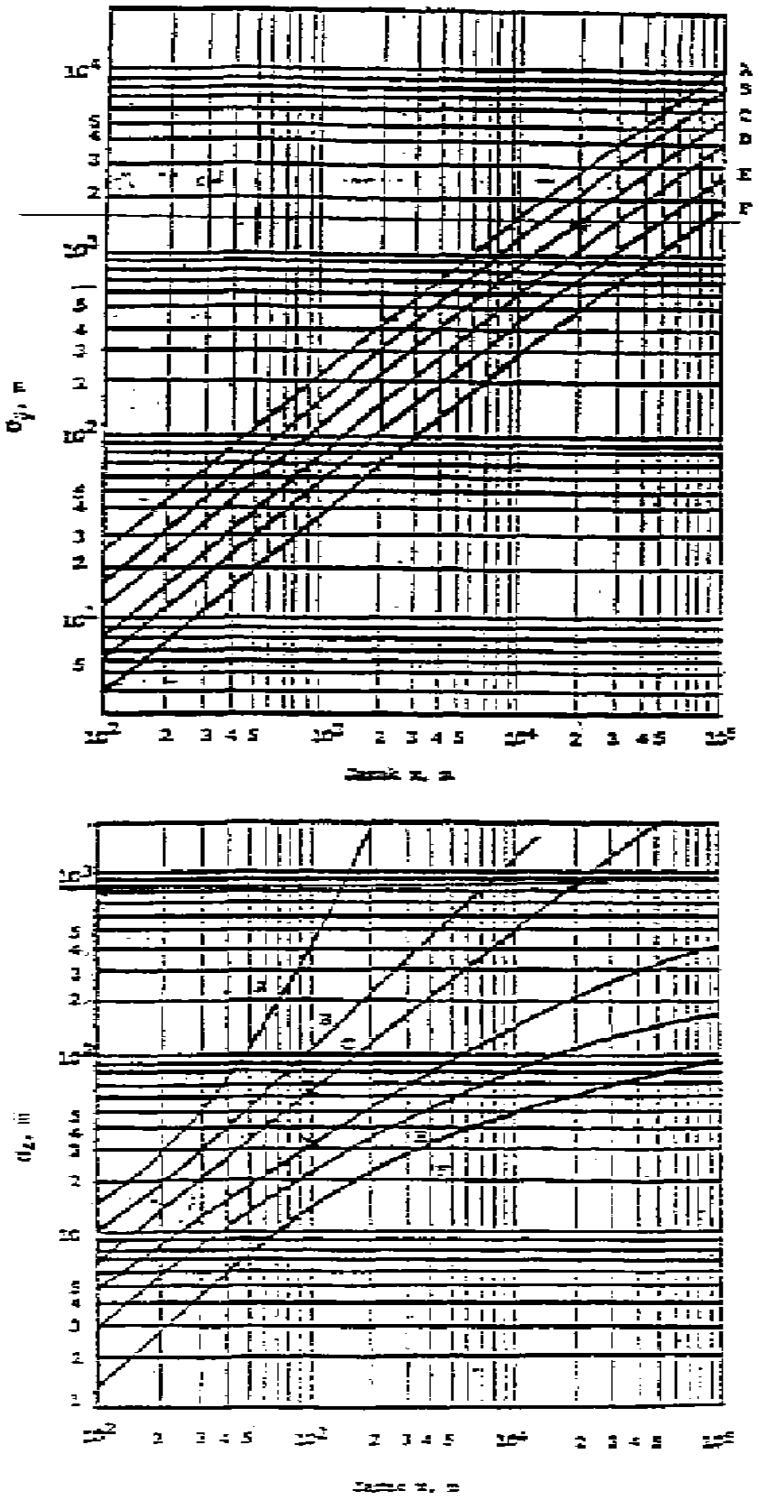
$$F = gVR^2 (T - T_A / T)$$

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

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

…25/-

PLOTS PASQUILL –GIFFORD



Jadual pekali untuk nilai σ_Z

Kelas Kestabilan Atmosfera	Jarak Dihilir angin (meter) 100 < x ≤ 500		Jarak Dihilir angin (meter) 500 < x ≤ 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 ≥ 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

WQI FORMULA AND CALCULATION

FORMULA

$$WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)$$

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

PERSAMAAN PEMADANAN TERBAIK UNTUK ANGGARAN NILAI SUBINDEKS

Subindex for DO (in % saturation)

$SIDO = 0$	for $x \leq 8$
$SIDO = 100$	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$

Subindex for BOD

$SIBOD = 100.4 - 4.23x$	for $x \leq 5$
$SIBOD = 108 * \exp(-0.055x) - 0.1x$	for $x > 5$

Subindex for COD

$SICOD = -1.33x + 99.1$	for $x \leq 20$
$SICOD = 103 * \exp(-0.0157x) - 0.04x$	for $x > 20$

Subindex for NH_3-N

$SIAN = 100.5 - 105x$	for $x \leq 0.3$
$SIAN = 94 * \exp(-0.573x) - 5 * \lvert x - 2 \rvert$	for $0.3 < x < 4$
$SIAN = 0$	for $x \geq 4$

Subindex for SS

$SISS = 97.5 * \exp(-0.00676x) + 0.05x$	for $x \leq 100$
$SISS = 71 * \exp(-0.0061x) - 0.015x$	for $100 < x < 1000$
$SISS = 0$	for $x \geq 1000$

Subindex for pH

$SIpH = 17.2 - 17.2x + 5.02x^2$	for $x < 5.5$
$SIpH = -242 + 95.5x - 6.67x^2$	for $5.5 \leq x < 7$
$SIpH = -181 + 82.4x - 6.05x^2$	for $7 \leq x < 8.75$
$SIpH = 536 - 77.0x + 2.76x^2$	for $x \geq 8.75$

	Stable Atmosphere	Neutral/Unstable Atmosphere
Buoyancy Dominated	$\Delta h(x) = 1.6F^{1/3} x^{2/3} U^{-1}$ (6) or $\Delta h_{MAX} = 2.6(F/Us)^{1/3}$ (7) where $s = 0.02g/T_A$ for E stability $s = 0.035g/T_A$ for F stability For sources located in Texas $s = 0.018g/T_A$ for E stability $s = 0.025g/T_A$ for F stability	$\Delta h(x) = 1.6F^{1/3} x^{2/3} U^{-1}$ (6) for $x < 3.5x^*$ or $\Delta h_{MAX} = 1.6F^{1/3}(3.5x^*)^{2/3} U^{-1}$ (8) for $x > 3.5x^*$ where $x^* = 14F^{5/8}$ if $F < 55$ $x^* = 34F^{2/5}$ if $F > 55$
Momentum Dominated	$\Delta h_{MAX} = 1.5(VR)^{2/3} U^{-1/3} s^{-1/6}$ (9) where s is defined as above	$\Delta h(x) = 3.78\left(\frac{V^2}{U(V+3U)}\right)^{2/3}\left(\frac{xR^2}{2}\right)^{1/3}$ (10) or $\Delta h_{MAX} = 3VD/U$ (11)

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

T = source temperature, °K

T_A = ambient temperature, °K

V = stack exit velocity, m/s

R = stack radius, m

D = stack diameter, m

x = downwind distance, m

U = wind speed at physical source height, m/s

g = acceleration due to gravity 9.8 m/s^2

Δh = plume rise, m

Δh_{MAX} = final plume rise, m

…29/-

Table 2. Stability Classification ("Procedures for Evaluation Air Quality Impact of New Stationary Sources", EPA)

Surface wind speed (m/s)	Daytime insolation			Nighttime	
	strong	moderate	slight	Thin overcast or > 4/8 low cloud cover	< 3/8 cloud cover
< 2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
> 6	C	D	D	D	D

Neutral class (D) is assumed for all overcast conditions during day or night.

Night is defined as the period from one hour before sunset to one hour after sunrise.

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