UNIVERSITI SAINS MALAYSIA

Peperiksaan Kursus Semasa Cuti Panjang
Sidang Akademik 2009/2010

June 2010

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 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) The chemical composition of algae is given as follows :

$C_{106}H_{18}O_{45}N_{16}P$

An analysis of a lake water sample provided values as listed below.

C = 62 mg/L; N = 0.08 mg/L dan P = 1.0 mg/L

State via a proper calculation , the specific limiting nutrient for the growth of algae in the lake based on the above monitored values.

(7 marks)

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

(7 marks)

(c) In a BOD analysis, 5 mL of wastewater was diluted to 300 mL with dilution water known to have dissolved oxygen (DO) value of 8.3 mg/L. After 5 days of incubation at 20°C, only 4 mg/L of DO was left in the BOD bottle. Assuming that the initial DO of the wastewater was zero and the deoxygenation coefficient, k (base e) was 0.23 day^{-1} at 20°C, calculate the BOD_u for this wastewater sample.

(6 marks)

2. (a) Water pollution depends on the definition of pollution, the characteristics and behaviour of the pollutants and the specific beneficial uses of the water itself.

(i) Provide the normal definition of water pollution.

(ii) List the main characteristics of water pollutants that are usually evaluated.

(iii) Give an example of pollution that can show the relationship between air, water and soil pollution.

(6 marks)

(b) (i) What do we mean by pE? What are the effects of a decreasing pE on the aquatic environment?

(ii) Calculate the concentration of Fe^{2+} in equilibrium with $Fe(OH)_3$ at pH 4 and pE 11.6. Use the following equation if needed.

$$Fe(OH)_3(s) + 3H^+ \rightleftharpoons Fe^{3+} + 3H_2O \quad , \quad K_{sp} = 9.1x10^{3}$$

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

(iii) Prove via a proper calculation that precipitation of $Fe(OH)_3$ occurs at pH 2.99 without the influence of pE by assuming that $[Fe^{3+}] = 1.00 \times 10^{-5}$ M.

(14 marks)

3. (a) Provide bacteria catalyzed reactions for the following processes:

(i) A process that occurs in an aerobic digester unit for a biological treatment plant.

(ii) A degradation process in an anoxic condition.

(iii) A degradation process in an anaerobic condition.

(6 marks)

(b) A seeded BOD analysis was done on a wastewater sample from a food processing industry. A BOD analysis on the seed water originating from an old sedimented wastewater was carried out by adding 20 mL of seed water into several 300 mL volume BOD bottles. They were then diluted to volume with diluting water. For the analysis of wastewater, 1.0 mL of wastewater together with 2.0 mL of seed water were added into several BOD bottles and diluted to volume with diluting water. The results of the analyses are given in the following table.

Time (days)	Seed Test B_2 (mg/L)	Sample test D_2 (mg/L)	Time (days)	Seed test B_2 (mg/L)	Sample test D_2 (mg/L)
0	8.0	8.0	7.9	4.5	4.1
1.0	7.3	7.2	9.8	4.1	3.8
1.9	6.5	6.4	11.8	3.9	3.5
2.9	5.9	5.8	14.0	3.4	2.9
3.8	5.5	5.3	15.6	3.6	2.7
4.7	5.1	5.0	19.0	3.8	2.1
6.0	4.8	4.6			

(i) Plot a BOD curve for this industrial wastewater.

(ii) Determine the value of BOD_5.

(iii) Determine the value of deoxygenation constant, k for this wastewater system.

(14 marks)

4. (a) Calculate the theoretical oxygen demand or ThOD for the wastewater sample that contained only 50 mg/L phenol (C_6H_5OH).

(4 marks)

(b) An industrial plant discharged its wastewater at a flowrate of 43 000 m^3 per day with BOD_u value of 350 mg/L into a river at a location A that has a BOD_u value of 2 mg/L. The flow of this river was at a rate of 10 m^3/s with the average speed of 12 m/min and temperature of 20°C. The DO analysis at location B, which was 1.74 days of water flow from location A showed that the river was in critical condition. Analyses of several main parameters of the river and the wastewater sample gave the following values:

C_s = 9.2 mg/L ; K_1 = 0.400 day^{-1} ; K_2 = 0.52 day^{-1} ; $D_\circ$ = 2.5 mg/L

(i) Calculate the value of DO at the location A.

(ii) Calculate the distance between locations A and B.

(iii) If the amount of DO at the location B must be maintained not less than 6.0 mg/L, what is the maximum value of the BOD_u of this wastewater that can be allowed to be discharged into the river ?

(iv) Explain how DO depletion occurs in the river water.

(16 marks)

Section B

5. (a) List three primary air pollutants that can cause the formation of smog. One of the secondary pollutants produced from smog is ozone. Provide the mechanism for the formation of ozone during smog episodes.

(5 marks)

(b) Give the mechanism for the formation and depletion of ozone in the stratosphere. What chemicals cause the depletion of ozone in the stratosphere?

(5 marks)

(c) Explain in detail the role of polar stratospheric cloud in the formation of ozone hole in the Antartic.

(10 marks)

6. (a) (i) For each case given in the table below, determine the temperature profile of the environment whether it is unstable, stable or neutral.

Cases	Intial temp °C	Final temp °C	Initial height ,m	Final height, m
A	127	-68	211	20,000
B	14	-31	456	1321
C	312	317	34	4235

(ii) Define the meaning of atmospheric inversion. How does radiation inversion occurs?

(8 marks)

(b) Acid rain phenomenon is due to the formation of sulphuric acid and nitric acid in the atmosphere. Provide proper mechanism for the formation of these acids. List the effects of acid rain on the environment.

(12 marks)

7. (a) Define the terms listed below:

(i) Adiabatic temperature change

(ii) Wet adiabatic lapse rate

(iii) Lofting plume

(6 marks)

(b) One of the problems from hydrocarbons discharged from car engines is the formation of peroxyacetylnitrate or PAN. Give chemical reactions leading to the formation of PAN from hydrocarbons.

(5 marks)

(c) An electrical power plant used 10 metric tones per hour of coal that contained 3 % sulphur. The effective stack height for this plant was 150 m. Determine the distance from the stack in the direction of the wind where the maximum concentration of SO_2 occurred and determine also the value of the maximum concentration that occurred. The speed of the wind at the height of the stack was 3.27 m/s and the atmospheric stability was taken to be C.

(9 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

Log r = log $(L_oK) - K_{10}t$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A table of values for σ_Z coefficients, where $\sigma_{Z=} ax^b$.

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, where $\sigma_{Y=} cx^d$.

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 $x \geq 8.75$

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) Komposisi kimia algae diberikan seperti berikut:

$$C_{106}H_{18}O_{45}N_{16}P$$

Satu analisis air tasik didapati memberikan nilai berikut:

C = 62 mg/L; N = 0.08 mg/L dan P = 1.0 mg/L

Nyatakan melalui perkiraan, unsur manakah yang menjadi penghad kepada pertumbuhan algae di dalam tasik tersebut.

(7 markah)

(b) Jelaskan dengan ringkas kenapa aktiviti antropogenik seperti penyahhutanan dan pertanian dianggap sebagai faktor-faktor yang membawa kepada peningkatan pencemaran air.

(7 markah)

(c) Dalam satu ujian BOD, 5 mL air buangan dicairkan kepada 300 mL dengan air pencairan yang mengandungi 8.3 mg/L oksigen terlarut. Selepas tempoh pengeraman selama 5 hari pada suhu 20°C, hanya 4 mg/L oksigen terlarut tertinggal dalam botol BOD. Andaikan bahawa oksigen terlarut awal bagi air buangan itu adalah sifar dan pemalar kadar k (dasar e) bernilai 0.23 per hari pada suhu 20°C, kiralah BOD_u air buangan ini.

(6 markah)

2 (a) Pencemaran air bergantung kepada definisi pencemaran, ciri-ciri dan sifat bahan pencemar serta kegunaan air itu sendiri.

(i) Berikan definisi pencemaran air.

(ii) Senaraikan ciri-ciri utama sifat bahan pencemar yang sering dinilai.

(iii) Berikan melalui satu contoh pertalian yang wujud di antara pencemaran udara, air dan tanah.

(6 markah)

(b) (i) Apakah yang dimaksudkan dengan pE ? Apakah kesan keatas persekitaran akuatik sekiranya pE menjadi semakin rendah?

(ii) Kiralah kepekatan Fe^{2+} dalam keseimbangan dengan $Fe(OH)_3$ pada pH 4 dan pE 11.6. Guna persamaan dibawah sekiranya perlu:

$$Fe(OH)_3\,(s) + 3H^{+} \rightleftharpoons Fe^{3+} + 3H_2O \quad , \quad K_{sp} = 9.1x10^{3}$$

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

(iii) Buktikan melalui perkiraan bahawa pemendakan $Fe(OH)_3$ berlaku pada pH 2.99 tanpa pengaruh pE dengan menganggap $[Fe^{3+}] = 1.00 \times 10^{-5}$ M.

(14 markah)

3. (a) Berikan tindakbalas rangsangan bakteria untuk proses-proses di bawah:

(i) Satu proses yang berlaku dalam unit penghadam aerobik bagi sesuatu loji pengolahan biologi.

(ii) Satu proses penguraian dalam keadaan anoksik.

(iii) Satu proses penguraian dalam keadaan anaerobik.

(6 markah)

(b) Satu analisis BOD berbenih telah dilakukan ke atas air buangan kilang memproses makanan. Analisis BOD ke atas air benih yang berasal daripada air buangan lama dan mendap dilakukan dengan memasukkan 20 mL air benih ini ke dalam beberapa botol BOD berisipadu 300 mL. Bagi menganalisis air buangan kilang, 1.0 mL air buangan kilang bersama 2.0 mL air benih dimasukkan ke dalam beberapa botol BOD. Keputusan daripada analisis ini disenaraikan di dalam jadual di bawah:

Masa (hari)	Ujian Benih B_2 (mg/L)	Ujian Sampel D_2 (mg/L)	Masa (hari)	Ujian Benih B_2 (mg/L)	Ujian Sampel D_2 (mg/L)
0	8.0	8.0	7.9	4.5	4.1
1.0	7.3	7.2	9.8	4.1	3.8
1.9	6.5	6.4	11.8	3.9	3.5
2.9	5.9	5.8	14.0	3.4	2.9
3.8	5.5	5.3	15.6	3.6	2.7
4.7	5.1	5.0	19.0	3.8	2.1
6.0	4.8	4.6			

(i) Plot keluk BOD untuk air buangan industri.

(ii) Tentukan nilai BOD_5

(iii) Tentukan nilai pemalar penyahoksigenan k untuk sistem air buangan ini.

(14 markah)

4. (a) Kira nilai tuntutan oksigen teori atau ThOD untuk sample air buangan yang mengandungi hanya 50 mg/L fenol (C_6H_5OH).

(4 markah)

(b) Suatu industri membuang air buangannya pada kadar aliran 43 000 m^3 per hari dengan nilai BOD_u 350 mg/L ke dalam satu sungai pada lokasi A yang mempunyai nilai BOD_u sebanyak 2 mg/L. Pengaliran sungai ini ialah 10 m^3/s dengan kelajuan purata 12 m/min dan suhunya 20°C. Analisis DO pada lokasi B, iaitu 1.74 hari pengaliran air daripada lokasi A menunjukkan ia dalam keadaan kritikal. Analisis beberapa parameter utama di kawasan sungai ini dan sampel air buangan memberikan nilai-niali di bawah:

C_s = 9.2 mg/L ; K_1 = 0.400 hari $^{-1}$; K_2 = 0.52 hari $^{-1}$; $D_\circ$ = 2.5 mg/L

(i) Kira nilai DO pada lokasi B di atas.

(ii) Kira jarak lokasi A daripada lokasi B.

(iii) Sekiranya amaun DO dilokasi B mahu dipastikan tidak kurang daripada 6.0 mg/L, berapakah nilai BOD_u air buangan industri yang boleh dibenarkan?

(iv) Jelaskan bagaimana DO berkurangan dalam air sungai.

(16 markah)

Bahagian B

5. (a) Senaraikan tiga pencemar primer yang mengakibatkan penghasilan asbut fotokimia. Salah satu pencemar sekunder yang terhasil daripada asbut fotokimia ialah ozon. Berikan mekanisme penghasilan ozon ini.

(5 markah)

(b) Berikan mekanisme penghasilan dan pelupusan ozon distratosfera. Apakah bahan kimia yang menyebabkan berlaku pelupusan ozon distratosfera.

(5 markah)

(c) Jelaskan dengan terperinci peranan awan kutub stratosferik (polar stratospheric cloud) dalam penghasilan lubang ozon di Antartika.

(10 markah)

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

Kes	Suhu awal °C	Suhu akhir °C	Ketinggian awal ,m	Ketinggian akhir, m
A	127	-68	211	20,000
B	14	-31	456	1321
C	312	317	34	4235

(ii) Berikan definasi sonsangan atmosfera. Bagaimanakah sonsangan sinaran berlaku?

(8 markah)

(b) Fenomena hujan asid adalah akibat penghasilan asid sulfurik dan asid nitrik dalam atmosfera. Berikan mekanisme pembentukan kedua-dua asid ini. Senaraikan kesan hujan asid ke atas persekitaran.

(12 markah)

7. (a) Berikan takrifan ke atas beberapa sebutan di bawah:

(i) Perubahan suhu adiabatik

(ii) Kadar langkau basah

(iii) Plum jenis "lofting"

(6 markah)

(b) Salah satu masalah pengeluaran hidrokarbon daripada enjin kereta ialah penghasilan peroksiasetilnitrat atau PAN. Berikan tindak balas bagaimana PAN boleh terhasil daripada hidrokarbon.

(5 markah)

(c) Sebuah loji janakuasa elektrik telah menggunakan 10 metrik ton per jam arang batu yang mengandungi 3 % sulfur. Ketinggian cerobong berkesan ialah 150 m. Tentukan jarak berlakunya kepekatan maksimum SO_2 dan tentukan juga nilai kepekatan maksimum yang berlaku. Kelajuan angin pada tahap ketinggian cerobong ialah 3.27 m/s dan kestabilan atmosfera ialah C.

(9 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

Log r = log $(L_oK) - K_{10}t$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Jadual pekali untuk nilai $\sigma_{Z,}$ dimana $\sigma_{Z} = ax^{b}$.

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 $\sigma_{Y,}$ dimana $\sigma_{Y} = cx^{d}$.

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

FORMULA DAN PERKIRAAN WQI

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 $x \geq 8.75$