UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

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 THIRTY pages of printed material.

Instructions:

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) Differentiate the following terms:

(i) Biomagnification and bioaccumulation

(ii) Persistent and biodegradable

(iii) Acute toxicity and chronic toxicity

(6 marks)

(b) What is likely to happen to a pollutant that has low water solubility and high octanol-water partition coefficient (K_{ow}) in the aquatic environment ?

(3 marks)

(c) Pb has a biological half-life of 4 years in the environment. An aquaculture pond has been contaminated with Pb. Analysis of Pb content in cockles in the pond was found to give an average value of 20 μg g^{-1}. Estimate the time required for the depuration process of the cockles so that the content of Pb will decrease to 5 μg g^{-1}.

(5 marks)

(d) A pollutant that enters an aquatic environment can undergo various transformation or fate. Explain what could possibly happen to a metal ion that is discharged into flowing river water.

(6 marks)

2. (a) Rivers A has been analyzed for its water quality parameters and the results are given in the following table. Determine its water quality index (WQI based on DOE method) and comments on the pollution status of this river.

River	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	7.3	3.7	23.9	0.7	6.87

(7 marks)

(b) Phosphorus and nitrogen are considered pollutants of the aquatic environment.

(i) Explain the effect of phosphorus pollution on the aquatic environment.

(ii) Explain how pH influences the transport of phosphate into a lake or river during a run-off.

(iii) Explain how ammoniacal nitrogen can consume oxygen in the aquatic environment.

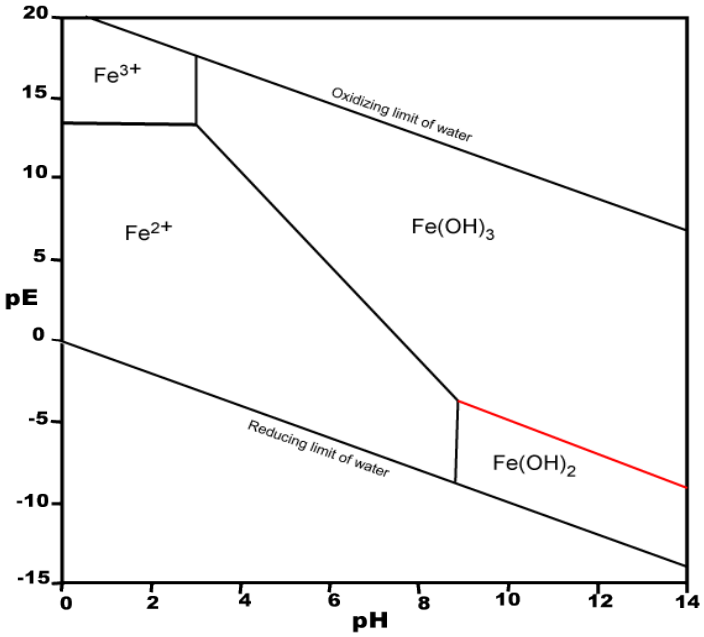
(13 marks)

3. (a) (i) What are the effects of heavy metal pollution on the environment?

(ii) How does the presence of ligands affect the behavior of metal ions in the aquatic environment?

(8 marks)

(b) The pE-pH diagram of Fe species in aquatic environment is given below.



(i) Based on your understanding of the pE-pH diagram above, explain why during sampling of a river water sample for metal analysis, the sample must be acidified quickly to pH 2 using nitric acid.

(ii) In Kelantan, the water supply is besieged with Fe causing poor water quality which affects the white color of washed linens. Explain by using proper chemical equations, which iron species is actually soiling the linen.

(iii) Based on the following chemical reactions at the boundaries, prove that the boundary line for $Fe^{2+}/Fe(OH)_3$ obeys the following equation :

$$pE = 22.2 - 3pH$$

1. $Fe^{3+} + e^- \rightarrow Fe^{2+}$ $pE^o = +13.2$ volts
2. $Fe(OH)_2 + 2\ H^+ \rightarrow Fe^{2+} + 2\ H_2O$ $K = 8 \times 10^{12}$
3. $Fe(OH)_3 + 3\ H^+ \rightarrow Fe^{3+} + 3\ H_2O$ $K = 9.1 \times 10^3$
4. $Fe(OH)_3 + e^- + 3\ H^+ \rightarrow Fe^{2+} + 3\ H_2O$
5. $Fe(OH)_3 + e^- + H^+ \rightarrow Fe(OH)_2 + H_2O$

(8 marks)

(c) Explain briefly why in the sampling of water samples for trace organic analysis, plastic bottles must not be used and the water samples need to be quickly stored at 4 ˚C.

(4 marks)

4. (a) Differentiate between the terms of chemical oxygen demand (COD) and biochemical oxygen demand (BOD). Why are BOD values always smaller than the COD values for the same water samples?

(5 marks)

(b) In a test for determination of BOD_5 of a sample from a polluted river stretch, three dilutions were used. The results of the calculations are given below.

Sample No	Dilution % mixture	Initial DO (mg L^{-1})	Final DO (mg L^{-1})
1	50	7.5	2.5
2	20	7.5	5.2
3	10	7.7	6.9

(i) Explain why the result for sample no. 3 is not acceptable and must be rejected.

(ii) Calculate the BOD_5 value of the polluted river stretch water sample based on the above results

(5 marks)

(c) Calculate the values of k and L_0 for the wastewater sample with the following BOD test data using the log-difference method.

t (days)	Y (mg L^{-1} of BOD)
0	0.0
1	9.2
2	15.9
3	20.9
4	24.4
5	27.2
6	29.1
7	30.6

(10 marks)

Section B

5. (a) A cannery discharges its wastes loaded with residual biomass into a nearby river water that caused downstream oxygen depletion. On a day when the temperature was 10^{o}C and water was flowing at a speed of 0.15 m s^{-1}, measurements of dissolved oxygen taken along the river indeed revealed oxygen depletion (sag curve) with a minimum level of 2.80 mg L^{-1} located 35.3 km downstream from the cannery. Upstream of the cannery, the dissolved oxygen level was 11.3 mg L^{-1}. The average depth of the river over the stretch under consideration was 2.1 m. The K_d was calculated to be 0.344 day^{-1}.

(i) Estimate the re-aeration rate (K_r, in day^{-1}) in the river.

(ii) What is the BOD in the river at the level of the cannery.

(iii) Assuming that this BOD comes exclusively from the cannery (no upstream BOD), by what percentage should the BOD of the cannery waste be reduced to insure a healthy stream with at least 5.0 mg L^{-1} of dissolved oxygen everywhere?

(9 marks)

(b) The World Health Organization issues guidelines for 8-hour ozone in mass concentration units to be 120 µg m^{-3}. What is this in ppm?

(3 marks)

(c) Explain how a chlorofluorocarbon (CFC) species such as CF_2Cl_2 causes depletion of ozone layer in the stratosphere.

(3 marks)

(d) One of the secondary pollutants generated during a smog episode is ozone. Provide the probable mechanism for its production?

(5 marks)

6. (a) Atmospheric precipitation is naturally a little acidic. Name the acid that is responsible for this . In addition and because of human pollution, there are two other acids now contributing to further increase the acidity of the rain water. Name these two acids and for each, provide the mechanism of its respective formation in the atmosphere.

(12 marks)

(b) Plot, on the same graph, the observed lapse rates from the following balloon temperature soundings:

Altitude (km)	Monday (^{o}C)	Tuesday (^{o}C)	Wednesday (^{o}C)
0	10.3	3	-5.8
0.1	9.4	2.1	-4.9
1.0	-0.2	-6.8	-15.0
1.1	-1.1	-6.0	-14.1
2.0	-10.5	-17.1	-20.2
2.1	-11.2	-17.0	-20.7
3.0	-22.9	-27.2	-25.3
4.0	-32.8	-37.0	-36.0

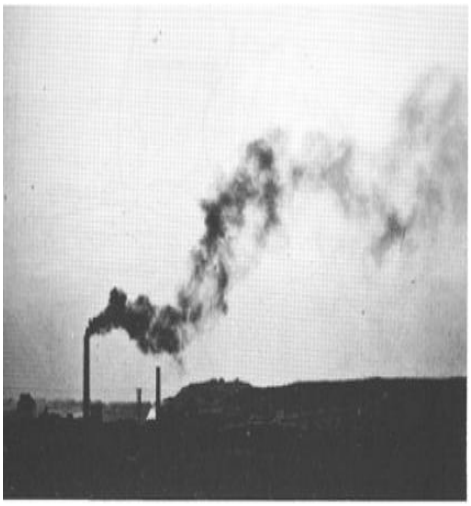
Identify the observed lapse rates and indicate whether the atmosphere is stable, neutral, or unstable with respect to vertical motions. For a constant source of local pollution located at the surface, which day is likely to have the worst air quality? Why?

(8 marks)

7. (a) For each of the smokestacks depicted below, tell whether its plume is coning, looping, fanning, fumigating, or lofting and provides the enviromental conditions that allow for its respective formation.

(a)

(b)



(c)

(ii) Determine the plume rise at a distance of 400 m downward from a stack (40 m high) if the buoyancy flux from the source is 50 m^4 s^{-3} and the wind velocity is 5 m s^{-1}.

(12 marks)

(b) I live three miles from a large coal fired power plant. Frequently the wind blows the power plant plume towards my house over a grassy field with a surface roughness (z_0) of 0.05 m. The average wind speed at 100 m height is 7 m s^{-1}. The plant currently emits sulfur dioxide at a rate of 1000 g s^{-1} from a 20 m stack. The plume is buoyant and rises to give an effective plume height of 100 m.

(i) Given these conditions, what are the concentrations at my front door under highly stable conditions?

(ii) Determine the magnitude and location of the maximum ground level concentration for the same conditions as in (i).

(8 marks)

Appendix

1. 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

2. 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

3. 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

4. Useful Equations

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

$L_t = L_oe^{-kt}$

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

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

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

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

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

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

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

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

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

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

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

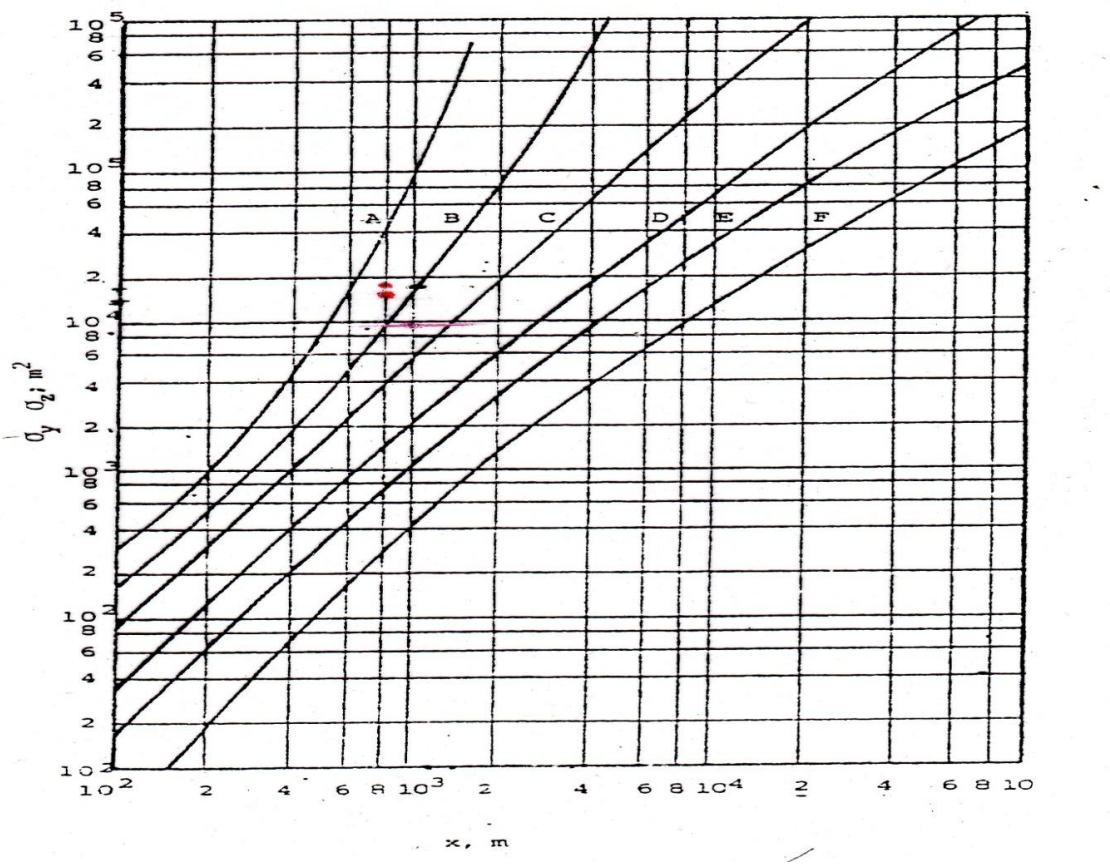
$$Y^* = 34F^{2/5}$$

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

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

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

5. PLOTS PASQUILL –GIFFORD



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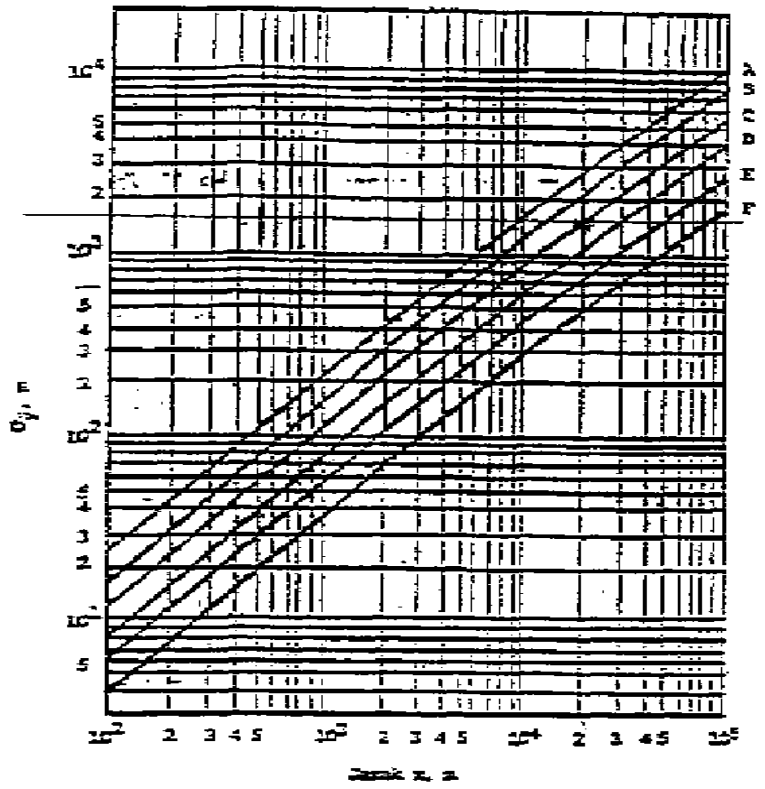
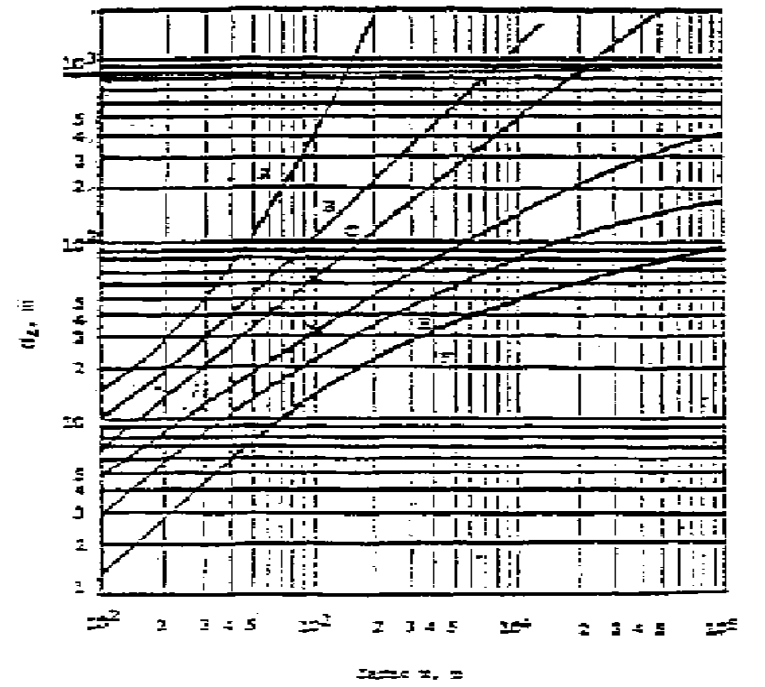




6. A table of values for σ_Z coefficients.

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	
	c	d	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

7. Relative atomic mass (RAM)

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

S= 32 and Fe = 55.8

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 $x \geq 8.75$

9.

	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

10. 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

Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA PULUH muka surat bahan bercetak

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) Bezakan sebutan-sebutan berikut:

(i) Biomagnifikasi dan pengumpulan biologi

(ii) Tegar dan biopenguraian

(iii) Ketoksikan akut dan ketoksikan kronik

(6 markah)

(b) Apakah yang akan berkemungkinan berlaku terhadap suatu bahan pencemar yang mempunyai keterlarutan air yang rendah dan pekali sekatan oktanol-air (K_{ow}) yang tinggi dalam persekitaran akuatik.

(3 markah)

(c) Pb mempunyai masa separa hayat 4 tahun dalam persekitaran. Satu kolam akuakultur telah dicemari Pb. Analisis kandungan Pb dalam kerang daripada kolam tersebut didapati memberikan nilai purata 20 µg g^{-1}. Anggarkan masa yang diperlukan untuk proses depurasi kerang tersebut agar kandungan Pb menurun kepada 5 µg g^{-1}.

(5 markah)

(d) Sesuatu bahan pencemar yang memasuki sebarang persekitaran akuatik boleh mengalami berbagai transformasi ataupun ketentuan. Jelaskan apa yang boleh berlaku ke atas suatu ion logam yang telah dilepaskan kedalam air sungai yang mengalir.

(6 markah)

2. (a) Parameter kualiti air sebuah sungai A telah di analisis dan hasilnya diberikan di dalam jadual berikut. Tentukan indeks kualiti air (WQI) sungai tersebut (berdasarkan kaedah DOE) dan komen terhadap status pencemaran sungai ini.

River	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	7.3	3.7	23.9	0.7	6.87

(7 markah)

(b) Fosforus dan nitrogen dianggap sebagai bahan pencemar persekitaran akuatik.

(i) Jelaskan apakah kesan pencemaran fosforus terhadap sesuatu persekitaran akuatik.

(ii) Terangkan bagaimana pH mempengaruhi pengangkutan fosfat kedalam sebuah tasik atau sungai semasa berlaku aliran air.

(iii) Terangkan bagaimana nitrogen berammonia boleh mengambil oksigen di dalam sesebuah persekitaran akuatik.

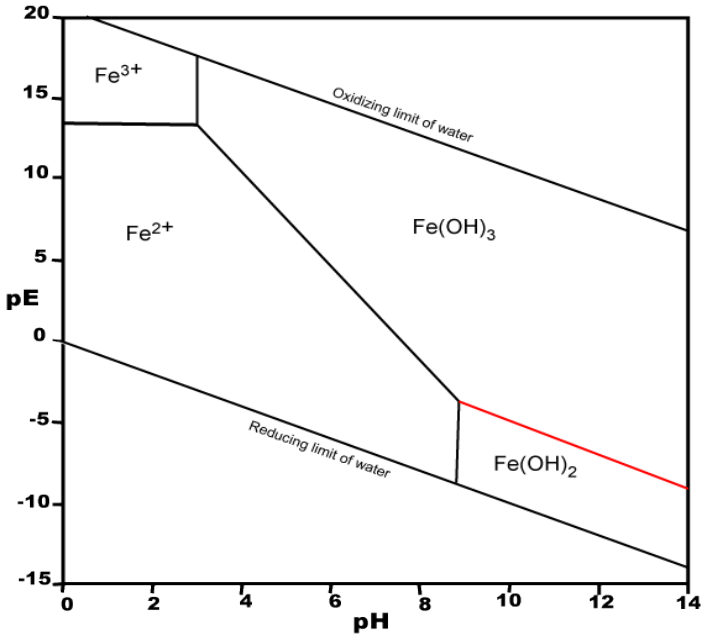
(13 markah)

3. (a) (i) Apakah kesan pencemaran logam berat terhadap persekitaran?

(ii) Bagaimanakah kehadiran ligan boleh mempengaruhi kelakuan ion logam dalam persekitaran akuatik.

(8 markah)

(b) Gambarajah pE-pH bagi spesies Fe dalam persekitaran akuatik diberikan dibawah.



(i) Berdasarkan kefahaman anda terhadap gambarajah pE-pH di atas, jelaskan kenapa sesuatu sampel air sungai untuk analisis logam perlu diasidkan dengan segera kepada pH 2 menggunakan asid nitrik.

(ii) Di Kelantan, bekalan air dicemari oleh Fe menyebabkan kualiti airnya rendah dan membawa kesan ke atas sebarang kain putih yang dibasuh. Dengan menggunakan persamaan kimia yang bersesuaian, jelaskan spesies besi yang bertanggung jawab ke atas pencemaran kain tersebut.

(iii) Berdasarkan persamaan kimia dipersempadanan berikut, buktikan bahawa garis sempadan untuk $Fe^{2+}/Fe(OH)_3$ mematuhi persamaan berikut:

$$pE = 22.2 - 3pH$$

1. $Fe^{3+} + e^- \rightarrow Fe^{2+}$ $pE^o = +13.2$ volts
2. $Fe(OH)_2 + 2\ H^+ \rightarrow Fe^{2+} + 2\ H_2O$ $K = 8 \times 10^{12}$
3. $Fe(OH)_3 + 3\ H^+ \rightarrow Fe^{3+} + 3\ H_2O$ $K = 9.1 \times 10^3$
4. $Fe(OH)_3 + e^- + 3\ H^+ \rightarrow Fe^{2+} + 3\ H_2O$
5. $Fe(OH)_3 + e^- + H^+ \rightarrow Fe(OH)_2 + H_2O$

(8 markah)

(c) Jelaskan secara ringkas kenapa dalam persampelan air untuk analisis organik surih, botol plastic tidak boleh digunakan dan sampel air tersebut perlu disimpan dengan segera pada 4 ˚C.

(3 markah)

4. (a) Bezakan di antara sebutan tuntutan oksigen kimia (COD) dan tuntutan oksigen biokimia (BOD_5). Kenapakah nilai BOD_5 sentiasa lebih kecil daripada nilai COD bagi setiap sampel air yang sama.

(5 markah)

(b) Dalam satu ujian BOD bagi suatu sampel daripada sebuah sungai tercemar, tiga pencairan telah digunakan. Keputusannya diberikan di bawah.

No Sampel	% campuran pencairan	DO awal (mg L^{-1})	DO akhir (mg L^{-1})
1	50	7.5	2.5
2	20	7.5	5.2
3	10	7.7	6.9

(i) Jelaskan kenapa keputusan no. 3 tidak boleh diguna pakai dan perlu ditolak.

(ii) Kiralah nilai BOD untuk sungai tercemar tersebut berdasarkan keputusan di atas.

(5 markah)

(c) Kira nilai K dan L_0 untuk satu sampel air buangan dengan nilai ujian BOD berikut menggunakan kaedah log-pembezaan.

t (hari)	Y (mg L^{-1} of BOD)
0	0.0
1	9.2
2	15.9
3	20.9
4	24.4
5	27.2
6	29.1
7	30.6

(10 markah)

Bahagian B

5. (a) Satu dicas sebuah kilang pengetinan yang sarat dengan residu biomass ke dalam sebuah sungai telah menyebabkan pelupusan oksigen di hilir sungai. Pada hari yang suhunya 10 C dan air mengalir pada kelajuan 0.15 ms^{-1}, pengukuran oksigen terlarut yang diambil disepanjang sungai sememangnya menunjukkan pelupusan oksigen (keluk kenduran) dengan para minimum pada 2.80 mg L^{-1} yang bertempat 35.3 km dihilir kilang pengetinan. Paras kandungan oksigen dihulu kilang pengentinan ialah 11.3 mg L^{-1}. Kedalaman purata sungai pada sepanjang kawasan yang dinilai ialah 2.1 m. Nilai K_d yang telah dikira ialah 0.344 $hari^{-1}$.

(i) Anggarkan kadar pengudaraan kembali (K_r, dalam per hari) untuk sungai ini.

(ii) Apakah nilai BOD di dalam air sungai pada lokasi separas dengan kilang pengetinan.

(iii) Dengan menganggap nilai BOD disumbangkan secara eksklusif oleh kilang pengetinan (tiada sumbangan BOD daripada hulu sungai), berapa peratuskah harus nilai BOD buangan kilang pengetinan ini perlu dikurangkan bagi memastikan sungai berkeadaan sihat dengan nilai oksigen terlarut di semua kawasannya berada sekurang-kurangnya pada 5.0 mg L^{-1} ?

(9 markah)

(b) Organisasi Kesihatan Dunia (WHO) telah mengeluarkan garis panduan untuk 8-jam ozon dalam unit kepekatan 120 µg m^{-3}. Apakah nilainya dalam ppm?

(3 markah)

(c) Jelaskan bagaimana spesies klrofluorokarbon seperti CF_2Cl_2 boleh menyebabkan pelupusan lapisan ozon di stratosfera.

(3 markah)

(d) Satu daripada bahan pencemar sekunder yang dijanakan semasa episod smog ialah ozon. Berikan mekanisme yang munasabah untuk penghasilannya.

(5 markah)

6. (a) Presipitasi atmosfera secara semulajadinya adalah sedikit berasid. Namakan acid yang bertanggung jawab ini. Tanbahan pula disebabkan oleh pencemaran manusia, terdapat dua lagi asid yang sekarang menyumbang kepada peningkatan keasidan air hujan. Namakan kedua-dua asid ini dan bagi setiap satu, berikan mekanisme penghasilan masing-masing di dalam atmosfera.

(12 markah)

(b) Plotkan pada graf yang sama, kadar langkau daripada suhu ukuran belon berikut. Kenalpastikan kadar langkau yang diperolehi dan tunjukkan samada atmosfera berkeadaan stabill, neutral atau tak stabil berdasarkan pergerakan menegak. Untuk satu sumber pencemaran setempat dipermukaan bumi, hari manakah berkemungkinan mempunyai kualiti udara terburuk. Kenapa?

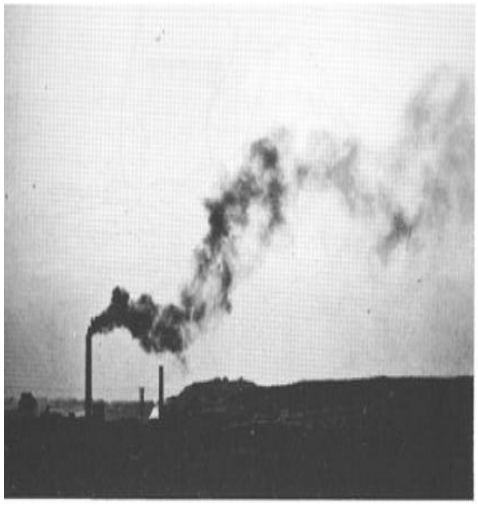
Altitud (km)	**Isnin (^oC)**	**Selasa (^oC)**	**Rabu (^oC)**
0	10.3	3	-5.8
0.1	9.4	2.1	-4.9
1.0	-0.2	-6.8	-15.0
1.1	-1.1	-6.0	-14.1
2.0	-10.5	-17.1	-20.2
2.1	-11.2	-17.0	-20.7
3.0	-22.9	-27.2	-25.3
4.0	-32.8	-37.0	-36.0

(8 markah)

7. (a) (i) Bagi setiap cerobong yang ditunjukkan di bawah, nyatakan sama ada plumnya berbentuk ‘coning’, ‘fanning’, ‘fumigating’ atau ‘lofting‘ dan berikan keadaan persekitaran yang menyebabkan berlakunya jenis-jenis plum tersebut.

(a)

(b)



(c)

(ii) Tentukan kenaikan plum pada jarak 400 m di bawah angin daripada cerobong (ketinggian 40 m) sekiranya fluks keapongan daripada sumbernya ialah 50 m^4s^{-3} dan kelajuan angin ialah 5 ms^{-1}

(6 markah)

(b) Saya tinggal 3 batu daripada sebuah loji janakuasa yang menggunakan arang batu. Kerapkali, angin meniupkan plum loji janakuasa tersebut kearah rumah saya melintasi sebuah padang rumput dengan kegasaran permukaan (z_0) 0.05 m. Kelajuan purata angin pada ketinggian 100 m ialah 7 m $s^{-1.}$ Pada masa kini, loji tersebut memancarkan sulfur dioksida pada kadar 1000 gs^{-1} daripada sebuah cerobong yang ketinggiannya ialah 20 m. Plum bersifat mengapong dan menaik untuk memberikan ketinggian plum berkesan setinggi 100 m.

(i) Pada keadaan yang diberikan di atas, apakah kepekatan SO_2 pada lokasi pintu depan rumah saya di bawah keadaan stabil yang tinggi.

(ii) Tentukan magnitud dan lokasi kepekatan maksimum paras bumi untuk keadaan (i) di atas.

(8 markah)

LAMPIRAN

1. 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

2. 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

3. 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

4. Persamaan

Log r = log (L_oK) – $K_{10}t$

$L_t = L_oe^{-kt}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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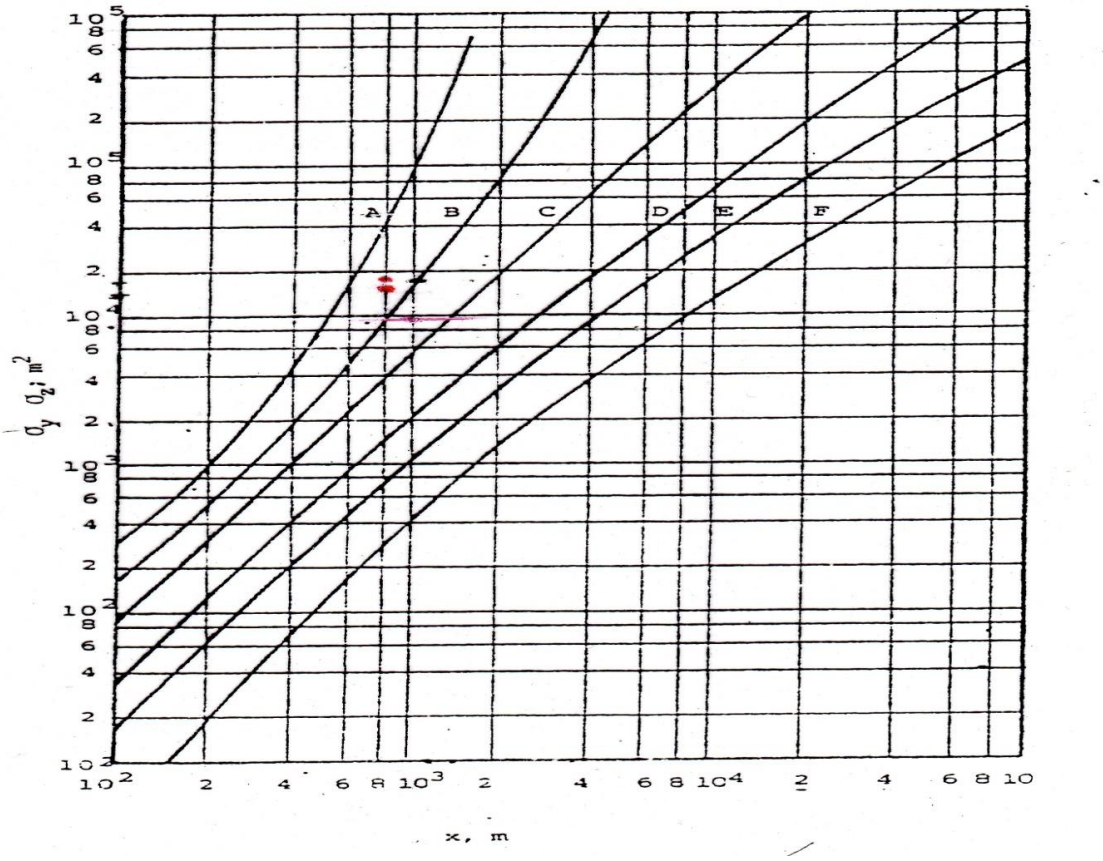
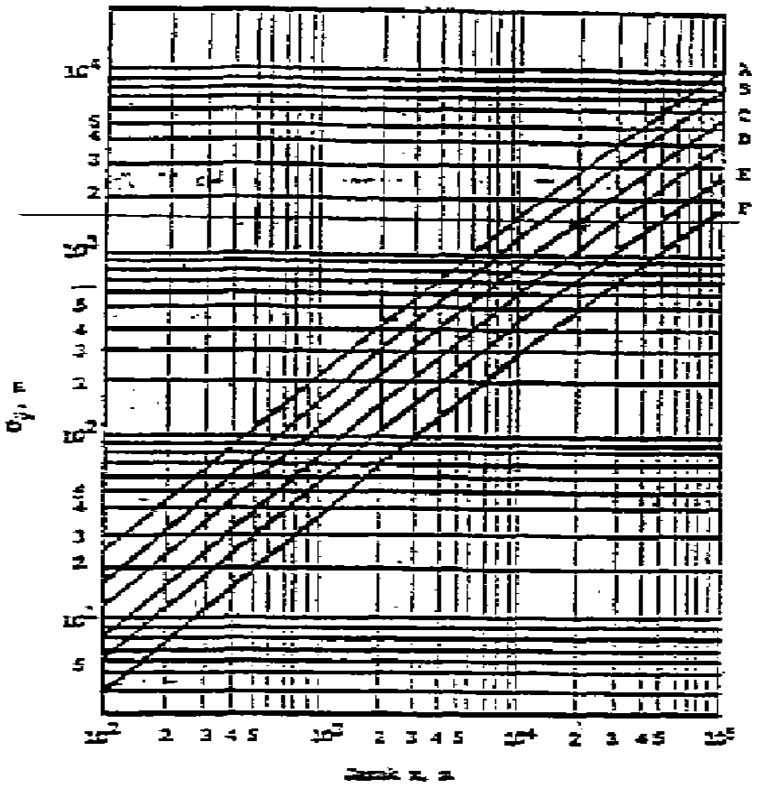
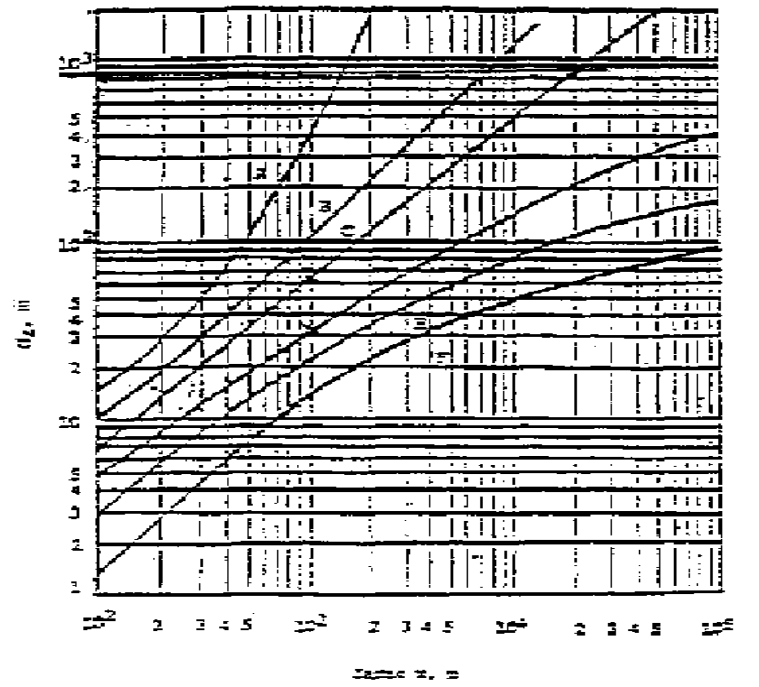
5. Keluk PASQUILL –GIFFORD







6. 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	
	c	**d**	**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

7. Jisim Atom Relatif (JAR)

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

S= 32 dan Fe = 55.8

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 $x \geq 8.75$

9.

	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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10. 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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