UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2009/2010 Academic Session

April/May 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 FOUR 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. Dichlorodiphenyltrichloroethane (DDT), an insecticide once used to control vectors is a chemical that is highly guarded in the environment because it fulfills all the criteria and characteristics of an environmental pollutant.

   (i) Discuss briefly why DDT is included in the list of environmental pollutants based on the main factors or criteria of evaluating pollutants.

   (ii) DDT is known to have high octanol-water partition coefficient (K_{ow}) and soil organic carbon-water partition coefficient (K_{oc}). Predict the fate of DDT in the aquatic environment.

   (iii) A species of fish was exposed to the pollution of DDT such that the accumulated DDT within the fish was determined to be 50 $\mu g\ g^{-1}$. If there would be no more exposure towards DDT after this incident and the half life of DDT is 160 days, what would be the concentration of DDT in the fish after 50 days of depuration?

   (iv) An analysis of DDT content in a food chain for an ecological system is given below:

Types of samples	**DDT concentration (mg kg^{-1})**
Water	0.00005
Plankton	0.04
Minnows	0.2-0.9
Predatory Fish	1.3-2.0
Predatory bird	6.0
Duck	22.8

   Explain this phenomenon.

(20 marks)

2. (a) The Malaysian Department of Environment provides a guideline for the determination of water quality index (WQI), which involves monitoring of six parameters (pH, DO, BOD, COD, AN and TSS). The water quality of a river was monitored and the results are given in the table below. Calculate the WQI of the river and comment on the pollution status of this river.

Parameters	**Results**
pH	7.3
DO (mg L^{-1})	6.8
Temp (°C)	28.7
TDS (mg L^{-1})	112.7
TSS (mg L^{-1})	8.4
Turbidity (FTU)	7.0
COD (mg L^{-1})	23.9
BOD (mg L^{-1})	3.7
NO_3^- (mg L^{-1})	0.38
PO_4^{3-} (mg L^{-1})	0.47
NH_3-N (mg L^{-1})	0.7
SO_4^{2-} (mg L^{-1})	16.1

(13 marks)

(b) Explain the difference between water quality criteria and water quality standard. Explain why it is not wrong for Malaysia to use a maximum allowable concentration of mercury in standard A as 5 ppb even though the European Community and world health organization (WHO) set it at 1 ppb.

(7 marks)

3. The results for the analysis of a lake water sample is given below.

TOC	100 mg L^{-1}
PO_4^{3-}	0.8 mg L^{-1}
Total N	2.0 mg L^{-1}
pH	7.0
Ca^{2+}	Non detectable

(i) Prove via a calculation that this lake will undergo a eutrophication based on the biological cell formula : $C_{106}\ H_{18}\ O_{45}\ N_{16}\ P$. (Atomic mass: P=31, N=14, C=12, O=16)

(ii) Provide a sample pretreatment scheme and brief analytical outline for the determination of total organic phosphorous of the lake water using a colorimetric method involving ascorbic acid.

(iii) Explain why in most cases, remediation of a phosphate polluted lake has to involve not only controlling the entry of phosphate into the lake but also dredging the lake sediment.

(20 marks)

4. (a) The following data can be used to build pE-pH diagram for the iron species in an aquatic system.

Maximum concentration of $[Fe^{2+}] = [Fe^{3+}] = 10^{-3}$ M

$[HCO_3^-] = 1.0 \times 10^{-2}$ M
$[CO_3^{2-}] = 1.0 \times 10^{-2}$ M

Atmospheric pressure = 1.00 atm

$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ $\quad pE^0 = +13.2$

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

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

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

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

$$pE = 15.3 - 2pH$$

(10 marks)

(b) Explain the following statements :

(i) Based on their biochemical effects, the presence of heavy metals in the aquatic environment is considered hazardous to humans and aquatic ecosystem.

(ii) The presence of ligands can influence the impact of metal pollution on the aquatic environment.

(10 marks)

Section B

5. (a) A BOD analysis was carried out on a wastewater from a factory. For this analysis, 10 mL of the wastewater was placed inside several BOD bottles and then each diluted to 300 mL. The results of a series of analyses are given in the table below.

(i) Determine the BOD_5 value for this wastewater.
(ii) Calculate the deoygenation constant value, k for this wastewater.
(iii) Find the BOD ultimate of the wastewater
(iv) Explain why there were no changes during the first two days of incubation.
(v) Find the BOD ultimate of the wastewater

Hari	DO (mg L^{-1})	Hari	DO (mg L^{-1})
0	9	5	4
1	9	6	3
2	9	7	2
3	6	8	1
4	5	9	0.5

(10 marks)

(b) A factory discharged its wastewater at a rate of 1.05 m^3 s^{-1} while the effluent from its wastewater treatment plant has a BOD_5 of 28 mg L^{-1}. The temperature of the effluent was 25 °C and its dissolved oxygen (DO) value was 1.8 mg L^{-1}. The water flow of the river was 8.0 m^3 s^{-1} at a speed of 0.37 m s^{-1}. The average depth of the river was 2.4 m. The temperature of the river water prior to mixing with the wastewater was 24 °C. The river water was 85 % saturated with DO and its BOD_5 was 3.6 mg L^{-1}. The deoxygenation constant, k_1 (based 10) was 0.5 day^{-1}. Determine:

(i) The distance of the minimum DO downstream from the discharge location.

(ii) The value of the minimum DO at that location.

(10 marks)

6. (a) Smog is an air pollution phenomenon that resulted in various hazardous and unhealthy conditions.

(i) Provide four factors or chemical species that must be present for the production of smog.

(ii) Explain how ozone and peroxylacylnitrate can be generated from the smog.

(iii) Explain the meaning and effect of subsidence inversion on the air pollution.

(10 marks)

(b) SO_2 is discharged a rate of 160 g s^{-1} from a stack with an effective height of 60 m. The wind speed at the height of the stack was 6 m s^{-1} and the atmospheric stability was assumed to be D.

(i) Determine the concentration of SO_2 at ground level along the centre line at a distance of 500 m from the stack in units of $\mu g\ m^{-3}$.

(ii) Find the concentration of SO_2 at the crosswind at a distance of 10 m off the 500 m along the centerline in units of ppm.

(10 marks)

7. (a) There are two species of air pollutants that cause global environmental impact namely NO and SO_2 . NO_2 is an oxidized product of NO.

(i) SO_2 has been known to cause acid rain. Explain how SO_2 can be converted into acid rain in the atmosphere.

(ii) NO and NO_2 play a significant role in the depletion of the ozone layer. Explain how these two species are able to deplete the ozone layer once they are in the stratosphere.

(12 marks)

(b) A traffic density of a highway was 10,000 vehicles per hour. The average speed of the vehicles was 80 km per hour. The wind speed perpendicular to the highway was found to be 3 m s^{-1}. The average carbon dioxide (CO) emission per vehicle was 20 g km^{-1}. On an overcast day, the atmospheric stability was assumed to be C. Determine the CO concentration at the location of i) 200 m and ii) 2 km in the direction of the wind from the highway.

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

$L_t = L_o e^{-kt}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 $x \geq 8.75$

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. Diklorodifeniltriklroethana (DDT), sejenis racun makhluk perosak yang pernah digunakan untuk mengawal vektor adalajh sejenis bahan kimia yang dikawal ketat kehadiranya dalam alam sekitar kerana ia memenuhi kesemua kriteria dan ciri-ciri sebagai bahan pencemar persekitaran.

   (i) Bincangkan dengan ringkas kenapa DDT dimasiukkan ke dalam senarai bahan pencemar persekitaran berdasarkan faktor dan kriteria utama penilaian sesuatu bahan pencemar.

   (ii) DDT diketahui mempunyai pekali sekatan oktanol-air ($Kow_)$ dan pekali sekatan karbon organik tanah -air (Koc) yang tinggi. Ramalkan ketentuan DDT dalam persekitaran akuatik.

   (iii) Sejenis spesies ikan terdedah kepada pencemaran DDT menyebabkan kandungan total DDT yang terkumpul didalamnya ialah 50 $\mu g\ g^{-1}$. Sekiranya tiada lagi pendedahan terhadap DDT berlaku selepas itu dan masa separa hayat DDT ialah 160 hari, berapakah kandungan DDT dalam ikan ini selepas 50 hari depurasi?

   (iv) Satu analisis kandungan DDT dalam rangkaian makanan bagi satu sistem ekologi diberikan di bawah:

Jenis sampel	**Kepekatan DDT ($mg\ kg^{-1}$)**
Air	0.00005
Plankton	0.04
Ikan kecil	0.2-0.9
Ikan pemangsa	1.3-2.0
Burung pemangsa	6.0
Itik	22.8

   Jelaskan fenomena ini.

(20 markah)

2. (a) Jabatan Alam Sekitar Malaysia menyediakan satu garis panduan untuk menentukan indeks kualiti air (WQI) yang melibatkan pemmonitoran enam parameter (pH, DO, BOD,COD,AN dan TSS). Kualiti air sebuah sungai telah dimonitor dan keputusannya diberikan dalam jadual dibawah. Kira WQI untuk sungai tersebut dan komen tentang status pencemaran sungai ini.

Parameter	**Keputusan**
pH	7.3
DO (mg L^{-1})	6.8
Temp (°C)	28.7
TDS (mg L^{-1})	112.7
TSS (mg L^{-1})	8.4
Turbidity (FTU)	7.0
COD (mg L^{-1})	23.9
BOD (mg L^{-1})	3.7
NO_3^- (mg L^{-1})	0.38
PO_4^{3-} (mg L^{-1})	0.47
NH_3-N (mg L^{-1})	0.7
SO_4^{2-} (mg L^{-1})	16.1

(13 markah)

(b) Jelaskan perbezaan di antara kriteria kualiti air dan piwai kualiti air. Jelaskan kenapa tidak salah untuk Malaysia menggunakan nilai kepekatan maksimum yang dibenarkan unt5uk merkuri dalam piawai A sebagai 5 ppb walapun ’Euopean Community’ dan Organisasi Kesihatan Dunia menetapkannya pada 1 ppb.

(7 markah)

3. Satu analisis air tasik memberikan nilai berikut:

TOC	100 mg L^{-1}
PO_4^{3-}	0.8 mg L^{-1}
Total N	2.0 mg L^{-1}
pH	7.0
Ca^{2+}	Non detectable

(i) Buktikan melalui perkiraan bahawa tasik ini pasti mengalami masalah eutrofikasi berdasarkan formula sel : C_{106} H_{18} O_{45} N_{16} P. (Jisim atom relatif: P=31, N=14, C=12, O=16).

(ii) Berikan satu skema pre-pegolahan sampel dan garis kasar analisis untuk penentuan fosoforus organik total untuk air tasik tersebut menggunakan kaedah kolorimetri melibatkan asid askorbik.

(iii) Jelaskan kenapa perawatan tasik tercemar fosfat perlu melibatkan pengorekan enapan dan bukan sekadar mengawal kemasukan fosfat.

(20 markah)

4. (a) Data di bawah boleh digunakan untuk membina gambarajah pE-pH spesies besi dalam persekitaran akuatik.

Kepekatan maksimum $[Fe^{2+}] = [Fe^{3+}] = 10^{-3}$ M

$[HCO_3^-] = 1.0 \times 10^{-2}$ M

$[CO_3^{2-}] = 1.0 \times 10^{-2}$ M

Tekanan atmosfera = 1.00 atm

$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ $\quad pE^0 = +13.2$

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

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

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

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

$$pE = 15.3 - 2pH$$

(10 markah)

(b) Jelaskan ungkapan–ungkapan berikut:

(i) Berdasarkan kesan biokimia, kehadiran logam berat di dalam persekitaran akuatik dianggap merbahaya.

(ii) Kehadiran ligan boleh mempengaruhi kesan pencemaran logam berat ke atas perskitaran akuatik.

(10 markah)

Bahagian B

5. (a) Satu analisis BOD telah dilakukan ke atas air buangan sebuah kilang. Untuk analisis ini, 10 mL air buangan ini dimasukkan ke dalam beberapa botol BOD dan dicairkan kepada 300 mL. Keputusan daripada ujian bersiri ini disenaraikan di dalam jadual di bawah:

Days	DO (mg L^{-1})	Days	DO (mg L^{-1})
0	9	5	4
1	9	6	3
2	9	7	2
3	6	8	1
4	5	9	0.5

(i) Tentukan nilai BOD_5 untuk air buangan ini.

(ii) Jelaskan kenapa tidak terdapat perubahan semasa dua hari pertama pengeramam.

(iii) Kira nilai pemalar penyahoksigenan, k untuk air buangan ini.

(iv) Dapatkan nilai BOD ultimat untuk air buangan ini.

(10 markah)

(b) Sebuah kilang mengeluarkan air buangan pada kadar 1.05 m^3 s^{-1} dan efluen loji pengolahan air buangannya mempunyai nilai BOD_5, 28 mg L^{-1}. Suhu air uangan ialah 25 °C dan kiandungan oksigen terlarut (DO) efluen loji ialah 1.8 mg L^{-1}. Aliran sungai ialah 8.0 m^3 s^{-1} pada kelajuan 0.37 m s^{-1} dengan purata kedalaman sungai pada 2.4 m. Suhu air sungai sebelum bercampur dengan air buanean ialah 24 °C. Sungai tersebut berada pada paras 85% tepu oksigen dengan nilai BOD_5, 3.6 mg L^{-1}. Pemalar penyahopksigenan, k_1 (pada dasar 10) ialah 0.5 per hari. Tentukan:

(i) Jarak untuk DO minimum di hilir sungai daripada lokasi discaj.

(ii) Nilai DO minimum pada lokasi tersebut.

(10 markah)

6. (a) Asbut adalah satu fenomena yang terhasil daripada pencemaran udara yang mengakibatkan beberapa kesan merbahaya dan tidak sihat.

(i) Berikan empat faktor atau species kimia yang perlu hadir untuk penghasilan asbut.

(ii) Jelaskan bagaimana ozon dan peroksilasilnirat terhasil daripada Asbut.

(iii) Jelaskan maksud dan kesan songsangan subsidens terhadap pencemaran udara.

(10 markah)

(b) SO_2 dikeluarkan dengan kadar 160 g s^{-1} dari satu cerobong asap yang tinggi berkesannya 60 m. Laju angin pada tinggi cerobong asap tersebut ialah 6 m s^{-1} dan kelas kestabilan atmosfera ialah D.

(i) Tentukan kepekatan di paras bumi disepanjang garis pusat ditempat yang jaraknya 500 m dari cerobong asap dalam unit $\mu g\ m^{-3}$.

(ii) Cari nilai kepekatan SO_2 dipersimpangan angin pada jarak 10 m daripada garis pusat pada jarak tersebut di atas dalam unit pp

(10 markah)

7. (a) Terdapat dua spesies bahan pencemar udara yang membawa kesan pencemaran global iaitu NO dan SO_2 . NO_2 ialah produk teroksida NO.

(i) SO_2 telah diketahui menyebabkan berlaku hujan asid. Jelaskan bagaimana SO_2 boleh menyebabkan hujan asid dalam atmosfera..

(ii) NO dan NO_2 memainkan peranan penting dalam penipisan lapisan ozon. Jelaskan bagaimana dua spesies ini mampu menipiskan lapisan ozon sebaik sahaja mereka berada dalam strosfera.

(12 markah)

(b) Ketumpatan trafik untuk satu lebuh raya adalah 10,000 kenderaan per jam dan laju purata kenderaan ialah 80 km sejam. Laju angin yang menegak dengan lebuh raya itu ialah 3 m s^{-1}. Pemancaran karbon dioksida (CO) purata per kenderaan adalah 20 g km^{-1}. Pada hari mendung dimana kestabilan udara adalah C, anggarkan kepekatan CO pada kedudukan i) 200 m dan ii) 2 km menurut arah angin daripada lebuh raya tersebut.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 $x \geq 8.75$

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