
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 $50 \mu\text{g g}^{-1}$. 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)

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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 ($^{\circ}\text{C}$)	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
$\text{NH}_3\text{-N}$ (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 : C₁₀₆ H₁₈ O₄₅ N₁₆ 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)

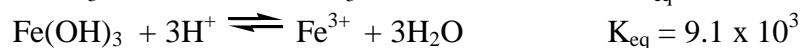
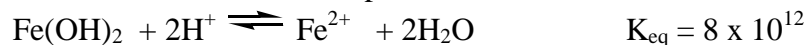
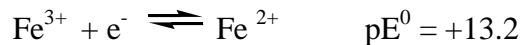
4. (a) The following data can be used to build pE-pH diagram for the iron species in an aquatic system.

Maximum concentration of [Fe²⁺] = [Fe³⁺] = 10⁻³ M

[HCO₃⁻] = 1.0 x 10⁻² M

[CO₃²⁻] = 1.0 x 10⁻² M

Atmospheric pressure = 1.00 atm



Prove that the boundary line for the Fe(OH)₃ - Fe(CO₃) in the pE-pH diagram obeys the following equation:

$$\text{pE} = 15.3 - 2\text{pH}$$

(10 marks)

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- (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 BOD₅ value for this wastewater.
- (ii) Calculate the deoxygenation 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)

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- (b) A factory discharged its wastewater at a rate of $1.05 \text{ m}^3 \text{ s}^{-1}$ while the effluent from its wastewater treatment plant has a BOD_5 of 28 mg L^{-1} . The temperature of the effluent was $25 \text{ }^\circ\text{C}$ and its dissolved oxygen (DO) value was 1.8 mg L^{-1} . The water flow of the river was $8.0 \text{ m}^3 \text{ s}^{-1}$ 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 $24 \text{ }^\circ\text{C}$. 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 peroxyacetyl nitrate can be generated from the smog.
 - (iii) Explain the meaning and effect of subsidence inversion on the air pollution.
- (10 marks)

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- (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.
- 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 $\mu\text{g m}^{-3}$.
 - 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 .
- SO_2 has been known to cause acid rain. Explain how SO_2 can be converted into acid rain in the atmosphere.
 - 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 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 temperature

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

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$$\text{Log } r = \log (L_0 K) - K_1 t$$

$$L_t = L_0 e^{-K_1 t}$$

$$D_t = \frac{K_1 L_0}{K_2 - K_1} (e^{-K_1 t} - e^{-K_2 t}) + D_0 e^{-K_2 t}$$

$$t_c = \left[\frac{1}{K_2 - K_1} \right] \ln \left[\frac{K_2}{K_1} \left(1 - D_0 \frac{K_2 - K_1}{L_0 K_1} \right) \right]$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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A table of values for σ_z coefficients.

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

A table for values of σ_y coefficients.

Atmospheric stability classes	Distance downwind (meter) $x < 10,000$		Distance downwind (meter) $x \geq 10,000$	
	a	b	c	d
	A = 1	.495	.873	.606
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

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WQI FORMULA AND CALCULATION**FORMULA**

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

where;

SIDO = Subindex DO (% saturation)

SIBOD = Subindex BOD

SICOD = Subindex COD

SIAN = Subindex NH₃-N

SISS = Subindex SS

SlpH = Subindex pH

$$0 \leq WQI \leq 100$$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES**Subindex for DO (in % saturation)**

$$SIDO = 0$$

$$SIDO = 100$$

$$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$$

$$\text{for } x \leq 8$$

$$\text{for } x \geq 92$$

$$\text{for } 8 < x < 92$$

Subindex for BOD

$$SIBOD = 100.4 - 4.23x$$

$$SIBOD = 108 * \exp(-0.055x) - 0.1x$$

$$\text{for } x \leq 5$$

$$\text{for } x > 5$$

Subindex for COD

$$SICOD = -1.33x + 99.1$$

$$SICOD = 103 * \exp(-0.0157x) - 0.04x$$

$$\text{for } x \leq 20$$

$$\text{for } x > 20$$

Subindex for NH₃-N

$$SIAN = 100.5 - 105x$$

$$SIAN = 94 * \exp(-0.573x) - 5 * |x - 2|$$

$$SIAN = 0$$

$$\text{for } x \leq 0.3$$

$$\text{for } 0.3 < x < 4$$

$$\text{for } x \geq 4$$

Subindex for SS

$$SISS = 97.5 * \exp(-0.00676x) + 0.05x$$

$$SISS = 71 * \exp(-0.0061x) - 0.015x$$

$$SISS = 0$$

$$\text{for } x \leq 100$$

$$\text{for } 100 < x < 1000$$

$$\text{for } x \geq 1000$$

Subindex for pH

$$SlpH = 17.2 - 17.2x + 5.02x^2$$

$$SlpH = -242 + 95.5x - 6.67x^2$$

$$SlpH = -181 + 82.4x - 6.05x^2$$

$$SlpH = 536 - 77.0x + 2.76x^2$$

$$\text{for } x < 5.5$$

$$\text{for } 5.5 \leq x < 7$$

$$\text{for } 7 \leq x < 8.75$$

$$\text{for } x \geq 8.75$$

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. Diklorodifeniltrikloethana (DDT), sejenis racun makhluk perosak yang pernah digunakan untuk mengawal vektor adalah sejenis bahan kimia yang dikawal ketat kehadirannya dalam alam sekitar kerana ia memenuhi kesemua kriteria dan ciri-ciri sebagai bahan pencemar persekitaran.
- (i) Bincangkan dengan ringkas kenapa DDT dimasukkan ke dalam senarai bahan pencemar persekitaran berdasarkan faktor dan kriteria utama penilaian sesuatu bahan pencemar.
 - (ii) DDT diketahui mempunyai pekali sekatan oktanol-air (K_{ow}) dan pekali sekatan karbon organik tanah -air (K_{oc}) yang tinggi. Ramalkan ketentuan DDT dalam persekitaran akuatik.
 - (iii) Sejenis spesies ikan terdedah kepada pencemaran DDT menyebabkan kandungan total DDT yang terkumpul didalamnya ialah $50 \mu\text{g g}^{-1}$. 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 pemantauan 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 ($^{\circ}\text{C}$)	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
$\text{NH}_3\text{-N}$ (mg L^{-1})	0.7
SO_4^{2-} (mg L^{-1})	16.1

(13 markah)

- (b) Jelaskan perbezaan di antara kriteria kualiti air dan piawai kualiti air. Jelaskan kenapa tidak salah untuk Malaysia menggunakan nilai kepekatan maksimum yang dibenarkan untuk merkuri dalam piawai A sebagai 5 ppb walaupun 'European Community' dan Organisasi Kesihatan Dunia menetapkan 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 : C₁₀₆ H₁₈ O₄₅ N₁₆ 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 fosforus 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)

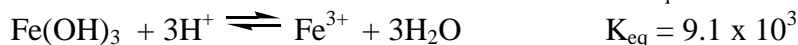
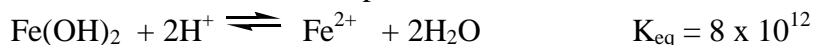
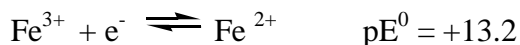
4. (a) Data di bawah boleh digunakan untuk membina gambarajah pE-pH spesies besi dalam persekitaran akuatik.

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

$$[\text{HCO}_3^-] = 1.0 \times 10^{-2} \text{ M}$$

$$[\text{CO}_3^{2-}] = 1.0 \times 10^{-2} \text{ M}$$

$$\text{Tekanan atmosfera} = 1.00 \text{ atm}$$



Buktikan bahawa sempadan untuk Fe(OH)₃ –Fe(CO₃) bagi gambarajah pE-pH mematuhi persamaan :

$$\text{pE} = 15.3 - 2\text{pH}$$

(10 markah)

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- (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 persekitaran 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 BOD₅ untuk air buangan ini.
- (ii) Jelaskan kenapa tidak terdapat perubahan semasa dua hari pertama pengaraman.
- (iii) Kira nilai pemalar penyahoksigenan, k untuk air buangan ini.
- (iv) Dapatkan nilai BOD ultimat untuk air buangan ini.

(10 markah)

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- (b) Sebuah kilang mengeluarkan air buangan pada kadar $1.05 \text{ m}^3 \text{ s}^{-1}$ dan efluen loji pengolahan air buangannya mempunyai nilai BOD_5 , 28 mg L^{-1} . Suhu air uangan ialah $25 \text{ }^\circ\text{C}$ dan kandungan oksigen terlarut (DO) efluen loji ialah 1.8 mg L^{-1} . Aliran sungai ialah $8.0 \text{ m}^3 \text{ s}^{-1}$ pada kelajuan 0.37 m s^{-1} dengan purata kedalaman sungai pada 2.4 m . Suhu air sungai sebelum bercampur dengan air buanean ialah $24 \text{ }^\circ\text{C}$. Sungai tersebut berada pada paras 85% tepu oksigen dengan nilai BOD_5 , 3.6 mg L^{-1} . Pemalar penyahoksigenan, k_1 (pada dasar 10) ialah 0.5 per hari. Tentukan:
- Jarak untuk DO minimum di hilir sungai daripada lokasi discaj.
 - 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.
- Berikan empat faktor atau species kimia yang perlu hadir untuk penghasilan asbut.
 - Jelaskan bagaimana ozon dan peroksilasilnirat terhasil daripada Asbut.
 - 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.
- Tentukan kepekatan di paras bumi disepanjang garis pusat ditempat yang jaraknya 500 m dari cerobong asap dalam unit $\mu\text{g m}^{-3}$.
 - 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 SO₂. NO₂ ialah produk teroksida NO.
- (i) SO₂ telah diketahui menyebabkan berlaku hujan asid. Jelaskan bagaimana SO₂ boleh menyebabkan hujan asid dalam atmosfera..
 - (ii) NO dan NO₂ 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)

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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

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$$\text{Log } r = \log (L_0 K) - K_1 t$$

$$L_t = L_0 e^{-K_1 t}$$

$$D_t = \frac{K_1 L_0}{K_2 - K_1} (e^{-K_1 t} - e^{-K_2 t}) + D_0 e^{-K_2 t}$$

$$t_c = \left[\frac{1}{K_2 - K_1} \right] \ln \left[\frac{K_2}{K_1} \left(1 - D_0 \frac{K_2 - K_1}{L_0 K_1} \right) \right]$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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Jadual pekali untuk nilai σ_z

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

Jadual pekali untuk nilai σ_y

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

Jisim Atom Relatif (JAR)

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

S = 32 dan Fe = 55.8

FORMULA DAN PERKIRAAN WQI**FORMULA**

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

where;

SIDO = Subindex DO (% saturation)

SIBOD = Subindex BOD

SICOD = Subindex COD

SIAN = Subindex NH₃-N

SISS = Subindex SS

SlpH = 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 NH₃-N

$$SIAN = 100.5 - 105x$$

for $x \leq 0.3$

$$SIAN = 94 * \exp(-0.573x) - 5 * |x - 2|$$

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

$$SlpH = 17.2 - 17.2x + 5.02x^2$$

for $x < 5.5$

$$SlpH = -242 + 95.5x - 6.67x^2$$

for $5.5 \leq x < 7$

$$SlpH = -181 + 82.4x - 6.05x^2$$

for $7 \leq x < 8.75$

$$SlpH = 536 - 77.0x + 2.76x^2$$

for $x \geq 8.75$