มหาวิทยาลัยสงขลานครินทร์
คณะวิศวกรรมศาสตร์

การสอบกลางภาค ประจำภาคการศึกษาที่ 1	ปีการศึกษา 2552
สอบวันที่ 2 สิงหาคม 2552	เวลา 09:00-12:00 น
วิชา 220-524 Waste Geotechnics	ห้องสอบ ห้องหัวหุ่น

ชื่อ..... รหัส.....

<u>คำชี้แจง</u>

1. ข้อสอบมี 4 ข้อ 100 คะแนน ให้ทำทุกข้อ
2. อนุญาตให้นักศึกษานำเครื่องคิดเลข และ กระดาษ Note ขนาด A4 เขียนด้านเดียว เข้าห้องสอบ

ผศ.ดร. ธนิต เฉลิมยานนท์
ผู้ออกข้อสอบ

Problem 1: Short Answers (15 points)

a. Explain the structures of clay minerals and how these structures create clay minerals?
b. Explain the negative charge of clay?
c. Explain the use of landfill and its main components. Also describe the function of each component.
d. Explain the process of mechanical dispersion?
e. Explain the effects of D and R on a breakthrough curve.

Problem 2: Cation Exchange (20 points)

A local soil (CEC of 45 meq/100g) in Hatyai of 500 g in weight contains 20% of sand, 25% of silt and 55 % of clay.

a. What is the weight of K that will satisfy the CEC?
b. What is the weight of Ca that will satisfy the CEC?
c. If this soil was first mixed with 500 ml of Na-Solution of 5000 mg/L, what is the weight of Mg required to satisfy the CEC?

Problem 3: Transport-Based Liner Design (30 points)

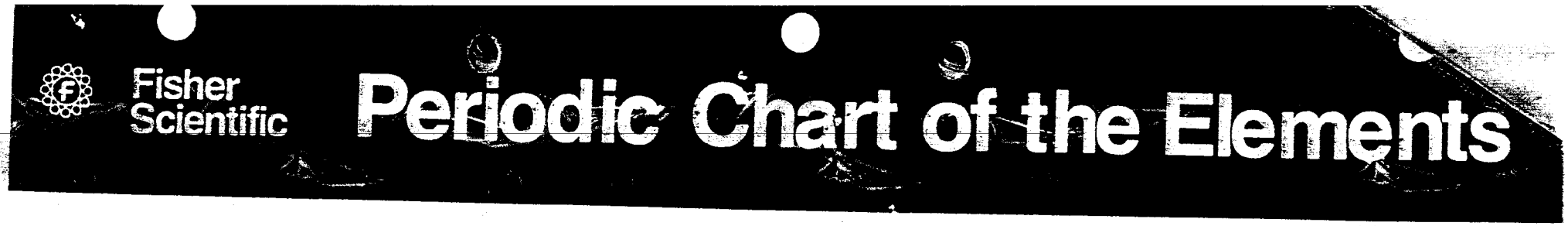
A composite liner consists of a 0.6 m compacted clay (K = $1x10^{-7}$ cm/s) overlain by a 1.5-mm thick HDPE geomembrane with a maximum depth of leachate of 0.3 m. Leachate of concern contains chromium and benzene. The concentrations of chromium and benzene in the leachate are 100 and 20 mg/L. The soil partitioning coefficients of chromium is 0.30 L/kg. Benzene is not adsorbed in clay. The soil diffusion coefficient for chromium and benzene are $1x10^{-6}$ and $5x10^{-6}$ cm^2/s respectively. The porosity of clay is 0.4, specific gravity is 2.7, and the dry density is 1.84 g/cc. Determine the mass flux (kg/ha/yr) of both chemicals at the bottom of liner at 40 years. Assume the diameter of the holes is 5 mm and 10 holes/ha. Note that for organic analysis, ignore the transport through holes.

Problem 4: A column test (35 points)

A column test was conducted using Songkhla clay (n = 0.35). The influent cadmium having concentration of 200 mg/L was placed on top of a 5-cm thick compacted clay sample which having the hydraulic conductivity of 1e-7 cm/s. Hydraulic gradient across the clay sample was 30. Observed effluent concentration with respect to time at the bottom of the column is shown in the table below. Given: the diffusion coefficient of 2e-6 cm^2/s and retardation factor of 20. Calculate the mean square error of this test. Students are requested to use Shackelford's equation (i.e., equation 3.16) with erfc function (see attached table) for this problem.

Table 1. Effluent concentration of cadmium obtained from the column test.

Time (days)	Eff. Concentration (mg/L)
50	0.09
100	40.02
150	136.7
200	188.4
250	192.1
300	194.3



1	2	3	4	5	6	7	8	9	10	11	12	•13	14	15	16	17	18	
1 IA IA	2 IIA IIA	3d IIIA IIIB	4d IVA IVB	5d VA VB	6d VIA VIB	7d VIIA VIIB	8d VIIIA VIIIB	9d VIIIA VIIIB	10d VIIIA VIIIB	11d IB IB	12d IIB IIB	13 ■ IIIB ★ IIIA	14 IVB IVA	15 VB VA	16 ‡ VIB VIA	17 VIIB VIIA	18 0 VIIIA	
1 **H** 1.00794△																1 **H** 1.00794△	2 **He** 4.002602*	2
3 **Li** 6.941*	4 **Be** 9.01218											5 **B** 10.811△	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994†	9 **F** 18.998403	10 **Ne** 20.179	2 8
11 **Na** 22.98977	12 **Mg** 24.305											13 **Al** 26.98154	14 **Si** 28.0855†	15 **P** 30.97376	16 **S** 32.066△	17 **Cl** 35.453	18 **Ar** 39.948	2 8 8
19 **K** 39.0983	20 **Ca** 40.078△	21 **Sc** 44.95591	22 **Ti** 47.88†	23 **V** 50.9415	24 **Cr** 51.9961△	25 **Mn** 54.9380	26 **Fe** 55.847†	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546†	30 **Zn** 65.39*	31 **Ga** 69.723△	32 **Ge** 72.59†	33 **As** 74.9216	34 **Se** 78.96†	35 **Br** 79.904	36 **Kr** 83.80	2 8 18 8
37 **Rb** 85.4678†	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224*	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07*	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.8682†	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.710△	51 **Sb** 121.75†	52 **Te** 127.60†	53 **I** 126.9045	54 **Xe** 131.29†	2 8 18 18 8
55 **Cs** 132.9054	56 **Ba** 137.33	57 ****La** 138.9055†	72 **Hf** 178.49†	73 **Ta** 180.9479	74 **W** 183.85†	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22†	78 **Pt** 195.08†	79 **Au** 196.9665	80 **Hg** 200.59†	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.9804	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)	2 8 18 32 18 8
87 **Fr** (223)	88 **Ra** 226.0254	89 **▼Ac** 227.0278	104 **Unq§** (261)	105 **Unp§** (262)	106 **Unh§** (263)													

• New IUPAC
■ Former IUPAC
♦ New Chemical Abstract Service
★ Former Chemical Abstract Service

**Lanthanides

58	59	60	61	62	63	64	65	66	67	68	69	70	71	
Ce 140.12	**Pr** 140.9077	**Nd** 144.24†	**Pm** (145)	**Sm** 150.36†	**Eu** 151.96	**Gd** 157.25†	**Tb** 158.9254	**Dy** 162.50†	**Ho** 164.9304	**Er** 167.26†	**Tm** 168.9342	**Yb** 173.04†	**Lu** 174.967	2 8 18 32 9 2

▼Actinides

90	91	92	93	94	95	96	97	98	99	100	101	102	103	
Th 232.0381	**Pa** 231.0359	**U** 238.0289	**Np** 237.0482	**Pu** (244)	**Am** (243)	**Cm** (247)	**Bk** (247)	**Cf** (251)	**Es** (252)	**Fm** (257)	**Md** (258)	**No** (259)	**Lr** (260)	2 8 18 32 32 9 2

FISHER SCIENTIFIC
CAT NO. 05-702-10

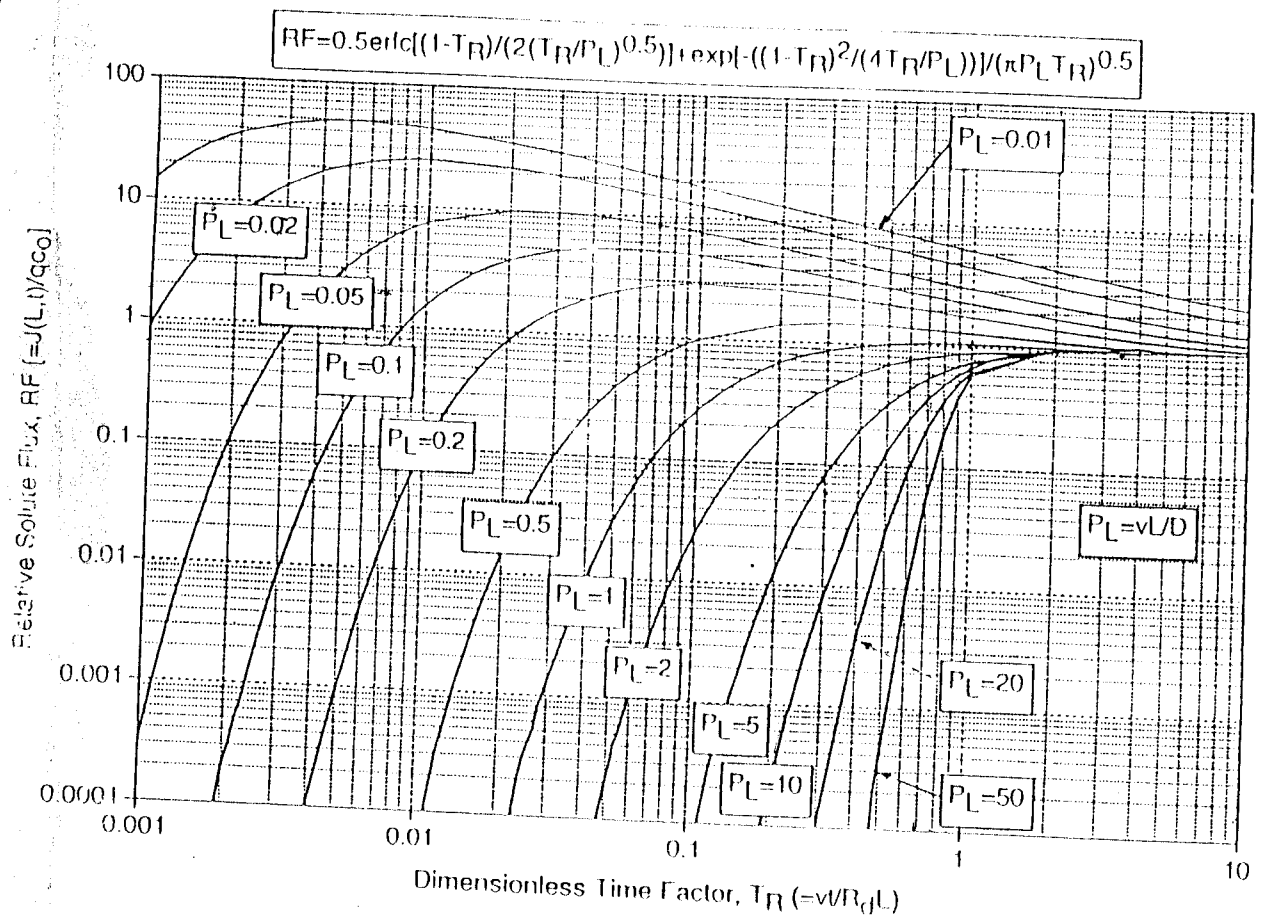
§The International Union of Pure and Applied Chemistry (IUPAC) has not adopted official names or symbols for these elements.

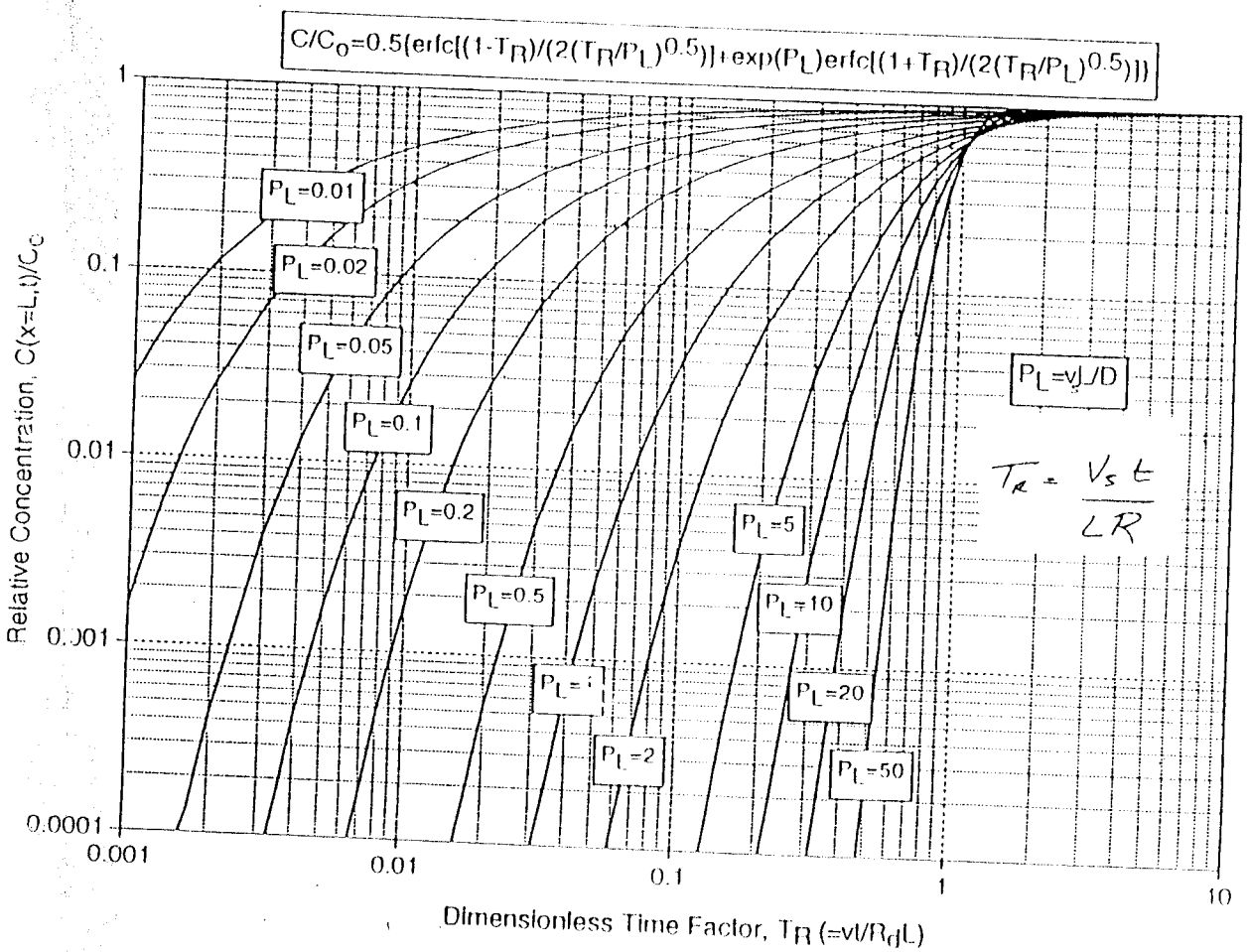
*These weights are considered reliable to ±2 in the last place.

†These weights are considered reliable to ±3 in the last place.

△These weights are considered reliable in the last place, as follows: Calcium and Gallium ±4; Boron ±5; Chromium and Sulfur ±6; Hydrogen and Tin ±7.
All other weights are reliable to ±1 in the last place. All reliabilities are based on an uncertainty scale of ±1 to 9.

Atomic weights corrected to conform to the most recent values of the Commission on Atomic Weights. Column nomenclature conforms to IUPAC system and data in this chart have been checked by the National Bureau of Standards' Office of Standard Reference Data.


RF=0.5erfc[(1-T_R)/(2(T_R/P_L)^0.5)]+exp[-((1-T_R)^2/(4T_R/P_L))]/(πP_L T_R)^0.5
Relative Solute Flux, RF [=J(L,t)/qc_o]
Dimensionless Time Factor, T_R (=vt/R_dL)
P_L=0.01
P_L=0.02
P_L=0.05
P_L=0.1
P_L=0.2
P_L=0.5
P_L=1
P_L=2
P_L=5
P_L=10
P_L=20
P_L=50
P_L=vL/D
100
10
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10


C/C_o=0.5{erfc[(1-T_R)/(2(T_R/P_L)^0.5)]+exp(P_L)erfc[(1+T_R)/(2(T_R/P_L)^0.5)]}
Relative Concentration, C(x=L,t)/C_o
Dimensionless Time Factor, T_R (=vt/R_dL)
P_L=0.01
P_L=0.02
P_L=0.05
P_L=0.1
P_L=0.2
P_L=0.5
P_L=1
P_L=2
P_L=5
P_L=10
P_L=20
P_L=50
P_L=vL/D
T_R = V_s t / LR
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10

ตารางที่ 3.1 ค่า Complementary error function

$$\mathrm{erfc}(\beta) = \left(\frac{2}{\pi}\right)\int_0^{\beta}\exp\left(-\varepsilon^2\right)d\varepsilon$$

$$\mathrm{erf}(-\beta) = -\mathrm{erf}(\beta)$$

$$\mathrm{erfc}(\beta) = 1 - \mathrm{erf}(\beta)$$

β	erf(β)	erfc(β)
0.00	0	1
0.05	0.056372	0.943628
0.10	0.112463	0.887537
0.15	0.167996	0.832004
0.20	0.222703	0.777297
0.25	0.276326	0.723674
0.30	0.328627	0.671373
0.35	0.379382	0.620618
0.40	0.428392	0.571608
0.45	0.475482	0.524518
0.50	0.520500	0.479500
0.55	0.563323	0.436677
0.60	0.603856	0.396144
0.65	0.642029	0.357971
0.70	0.677801	0.322199
0.75	0.711155	0.288845
0.80	0.742101	0.257899
0.85	0.770668	0.229332
0.90	0.796908	0.203092
0.95	0.820891	0.179109
1.00	0.842701	0.157299
1.10	0.880205	0.119795
1.20	0.910314	0.089686
1.30	0.934008	0.065992
1.40	0.952285	0.047715
1.50	0.966105	0.033895
1.60	0.976348	0.023652
1.70	0.983790	0.016210
1.80	0.989091	0.010909
1.90	0.992790	0.007210
2.00	0.995322	0.004678
2.10	0.997021	0.002979
2.20	0.998137	0.001863
2.30	0.998857	0.001143
2.40	0.999311	0.000689
2.50	0.999593	0.000407
2.60	0.999764	0.000236
2.70	0.999866	0.000134
2.80	0.999925	0.000075
2.90	0.999959	0.000041
3.00	0.999978	0.000022
3.50	0.999999	0.000001
4.00	1.000000	0.000000