

## Study Guide for Mid-term Exam

Approximate Relative importance: Homeworks>Slides>Book  
Mid-term exam covers lectures #1-17; topics below:

Topics	Book	Lecture# with advice on most important slides/concepts <sup>1</sup>	Date	Home-work	
<b>I. Introduction</b> <ul style="list-style-type: none"> <li>Environmental Engineering Overview, legislation</li> <li>Mass Balances</li> </ul>	Chapter 1	<u>1</u> Know terms, mass balances Slides 10-17	9 Sept		
		<ul style="list-style-type: none"> <li>Environmental Legislation &amp; Regulation</li> </ul>	<u>2</u> Slides 6, 37, 39, 47-50, 53-55	11 Sept	
<b>II. Environmental Chemistry</b> <ul style="list-style-type: none"> <li>Basics: Bonding &amp; definitions</li> <li>Units of concentration</li> <li>Reactions &amp; stoichiometry</li> <li>Equilibrium</li> <li>Kinetics</li> <li>Water, soil &amp; air chemistry</li> <li>Ionic strength</li> <li>Thermodynamics</li> <li>Acids &amp; Bases</li> <li>Equilibria, calculations</li> </ul>	Chapter 2&3	<u>3</u> Slides 2-12	14 Sept		
		<ul style="list-style-type: none"> <li>Organic Nomenclature</li> </ul>	<u>4</u> Slides: all	16 Sept	<u>#1</u>
			<u>5</u> Slides: all; no need to memorize equations on slide 17	18 Sept	<u>#2</u>
			<u>6</u> Slides 2-5, 6-10, 14-29	21 Sept	
			<u>7</u> Chemical names in slides 3, 22, 25, 26, but don't memorize the constants, slides 4-21, 27-32.	23 Sept	<u>#3</u>
			<u>8</u> Slides 2-11, 16-33	25 Sept	
<b>III. Physical Processes</b> <ul style="list-style-type: none"> <li>Mass balances; reactors</li> <li>Energy and Energy balances</li> <li>Microbiology &amp; Biochemical pathways</li> </ul>	Chapter 4	<u>9</u> Slides: all	28 Sept	<u>#4</u>	
			<u>10</u> Slides 4, 11-15	30 Sept	
			<u>11</u> Slides 2-24 (minus details in #15)	2 Oct	

<sup>1</sup> I've listed slides by number within each lecture as they are currently (Oct 27) posted on the CEE 370 website (<http://www.ecs.umass.edu/cee/reckhow/courses/370/sched.htm>). I generally don't list example problems, because the specifics of these aren't too important. They are useful, however, in learning to apply the important concepts. This is my best general assessment, but it isn't perfect. There may be a few questions on topics not listed among the most important slides.

<b>IV. Biological Principles</b> <ul style="list-style-type: none"> <li>• Basic principles</li> </ul>	<b>Chapter 5</b>	<u><a href="#">12</a></u> Slides 2-12 (no need to know exact structures of these organic molecules)	5 Oct	
<ul style="list-style-type: none"> <li>• Biochemical pathways</li> <li>• Energy transfer and yields</li> <li>• Enzymes</li> </ul>		<u><a href="#">13</a></u> Slides: all (but no need to know details of biochemical pathways or half-reactions and related constants)	7 Oct	
<ul style="list-style-type: none"> <li>• Genetics</li> <li>• Transcription</li> </ul>		<u><a href="#">14</a></u> Slides 2-4, 6, 9-17, 30-32, 47	9 Oct	
<ul style="list-style-type: none"> <li>• Microorganisms, organelles</li> </ul>		<u><a href="#">15</a></u> Slides: all (minus details of algal types; and species names)	13 Oct	
<ul style="list-style-type: none"> <li>• Water quantities</li> <li>• Nutrient cycles</li> </ul>		<u><a href="#">16</a></u> Slides 2-9 don't memorize fluxes or quantities, 11-25, 27, 29-49 (don't memorize values in slide 34)	14 Oct	
<ul style="list-style-type: none"> <li>• Growth models</li> </ul>		<u><a href="#">17</a></u> Slides: all	16 Oct	<u><a href="#">#5</a></u>

## Instructions provided with Exam

Closed Book, one sheet of notes allowed

## Special information provided with Exam

### Conversions

$$7.48 \text{ gallon} = 1.0 \text{ ft}^3 \quad 1 \text{ gal} = 3.7854 \times 10^{-3} \text{ m}^3$$

$$1 \text{ MGD} = 694 \text{ gal/min} = 1.547 \text{ ft}^3/\text{s} = 43.8 \text{ L/s}$$

$$1 \text{ ft}^3/\text{s} = 449 \text{ gal/min}$$

$$g = 32 \text{ ft/s}^2$$

$$W = \gamma = 62.4 \text{ lb/ft}^3 = 9.8 \text{ N/L}$$

$$1 \text{ hp} = 550 \text{ ft-lbs/s} = 0.75 \text{ kW}$$

$$1 \text{ mile} = 5280 \text{ feet} \quad 1 \text{ ft} = 0.3048 \text{ m}$$

$$1 \text{ watt} = 1 \text{ N-m/s}$$

$$1 \text{ psi pressure} = 2.3 \text{ vertical feet of water (head)}$$

$$\text{At } 60 \text{ }^\circ\text{F, } \nu = 1.217 \times 10^{-5} \text{ ft}^2/\text{s}$$

### Selected Chemical Constants

Element	Symbol	Atomic #	Atomic Wt.	Valence	Electronegativity
Aluminum	Al	13	26.98	3	1.47
Boron	B	5	10.81	3	2.01
Calcium	Ca	20	40.08	2	1.04
Carbon	C	6	12.01	2,4	2.50
Chlorine	Cl	17	35.453	1,3,5,7	2.83
Chromium	Cr	24	52.00	many	1.56
Helium	He	2	4.00	0	
Holmium	Ho	67	164.93	3	1.10
Hydrogen	H	1	1.01	1	2.20
Magnesium	Mg	12	24.31	2	1.23
Manganese	Mn	25	54.94	2,3,4,6,7	1.60
Nitrogen	N	7	14.01	many	3.07
Oxygen	O	8	16.00	2	3.50
Potassium	K	19	39.10	1	0.91
Sodium	Na	11	22.99	1	1.01
Sulfur	S	16	32.06	2,4,6	2.44

### Selected Acidity Constants (Aqueous Solution, 25°C, I = 0)

NAME	FORMULA	pK <sub>a</sub>
Hydrochloric acid	$\text{HCl} = \text{H}^+ + \text{Cl}^-$	-3
Sulfuric acid	$\text{H}_2\text{SO}_4 = \text{H}^+ + \text{HSO}_4^-$	-3

Nitric acid	$\text{HNO}_3 = \text{H}^+ + \text{NO}_3^-$	-0
Bisulfate ion	$\text{HSO}_4^- = \text{H}^+ + \text{SO}_4^{2-}$	2
Phosphoric acid	$\text{H}_3\text{PO}_4 = \text{H}^+ + \text{H}_2\text{PO}_4^-$	2.15
Hydrofluoric acid	$\text{HF} = \text{H}^+ + \text{F}^-$	3.2
Nitrous acid	$\text{HNO}_2 = \text{H}^+ + \text{NO}_2^-$	4.5
Acetic acid	$\text{CH}_3\text{COOH} = \text{H}^+ + \text{CH}_3\text{COO}^-$	4.75
Propionic acid	$\text{C}_2\text{H}_5\text{COOH} = \text{H}^+ + \text{C}_2\text{H}_5\text{COO}^-$	4.87
Carbonic acid	$\text{H}_2\text{CO}_3 = \text{H}^+ + \text{HCO}_3^-$	6.35
Hydrogen sulfide	$\text{H}_2\text{S} = \text{H}^+ + \text{HS}^-$	7.02
Dihydrogen phosphate	$\text{H}_2\text{PO}_4^- = \text{H}^+ + \text{HPO}_4^{2-}$	7.2
Hypochlorous acid	$\text{HOCl} = \text{H}^+ + \text{OCl}^-$	7.5
Ammonium ion	$\text{NH}_4^+ = \text{H}^+ + \text{NH}_3$	9.24
Hydrocyanic acid	$\text{HCN} = \text{H}^+ + \text{CN}^-$	9.3
Phenol	$\text{C}_6\text{H}_5\text{OH} = \text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$	9.9
Bicarbonate ion	$\text{HCO}_3^- = \text{H}^+ + \text{CO}_3^{2-}$	10.33
Monohydrogen phosphate	$\text{HPO}_4^{2-} = \text{H}^+ + \text{PO}_4^{3-}$	12.3
Bisulfide ion	$\text{HS}^- = \text{H}^+ + \text{S}^{2-}$	13.9

## PHYSICAL AND CHEMICAL CONSTANTS

Avogadro's number	$N = 6.022 \times 10^{23} \text{ mol}^{-1}$
Elementary charge	$e = 1.602 \times 10^{-19} \text{ C}$
Gas constant	$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ $= 1.987 \text{ cal mol}^{-1} \text{ K}^{-1}$ $= 0.08205 \text{ L atm mol}^{-1} \text{ K}^{-1}$
Planck's constant	$h = 6.626 \times 10^{-34} \text{ J s}$
Boltzmann's constant	$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$
Faraday's constant	$F = 9.649 \times 10^4 \text{ C mol}^{-1}$
Speed of light	$c = 2.998 \times 10^8 \text{ m s}^{-1}$
Vacuum permittivity	$\epsilon_0 = 8.854 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
Earth's gravitation	$g = 9.806 \text{ m s}^{-2}$

## CONVERSION FACTORS

1 cal	= 4.184 joules (J)
1 eV/molecule	= 96.485 kJ mol <sup>-1</sup> = 23.061 kcal mol <sup>-1</sup>
1 wave number (cm <sup>-1</sup> )	= 1.1970 × 10 <sup>-2</sup> kJ mol <sup>-1</sup>
1 erg	= 10 <sup>-10</sup> kJ
1 atm	= 1.01325 × 10 <sup>5</sup> Pa
1 Å	= 10 <sup>-10</sup> m
1 L	= 10 <sup>-3</sup> m <sup>3</sup>

## PROPERTIES OF WATER

T(°C)	$\rho$ , Density (kg · m <sup>-3</sup> )	$\mu$ Viscosity (kg · m <sup>-1</sup> · s <sup>-1</sup> )	$\sigma$ , Surface Tension against Air (J · m <sup>-2</sup> )	$\epsilon$ Dielectric Constant (C · V <sup>-1</sup> · m <sup>-1</sup> )	$pK_w$ , Ionization Constant (mol <sup>2</sup> · L <sup>-2</sup> )
0	999.868	0.001787	0.0756	88.28	14.9435
5	999.992	0.001519	0.0749	86.3	14.7338
10	999.726	0.001307	0.07422	84.4	14.5346
15	999.125	0.001139	0.07349	82.5	14.3463
20	998.228	0.001002	0.07275	80.7	14.1669
25	997.069	0.0008904	0.07197	78.85	13.9965
30	995.671	0.0007975	0.07118	77.1	13.8330

## SI PREFIXES

Multiplication Factor	Prefix	Symbol	Multiplication Factor	Prefix	Symbol
10 <sup>12</sup>	tera	T	10 <sup>-2</sup>	centi	c
10 <sup>9</sup>	giga	G	10 <sup>-3</sup>	milli	m
10 <sup>6</sup>	mega	M	10 <sup>-6</sup>	micro	$\mu$
10 <sup>3</sup>	kilo	k	10 <sup>-9</sup>	nano	n
10 <sup>2</sup>	hecto	h	10 <sup>-12</sup>	pico	p
10 <sup>1</sup>	deka	da	10 <sup>-15</sup>	femto	f
10 <sup>-1</sup>	deci	d	10 <sup>-18</sup>	atto	a