

OLLSCOIL NA hÉIREANN, GAILLIMH  
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SECOND SEMESTER EXAMINATIONS, 2000

B.E. DEGREE EXAMINATION

WASTE MANAGEMENT

Professor R. A. Falconer  
Professor P. O'Donoghue;  
Mr. M. Hartnett.  
Mr. B. Misstear  
Mr. P. Carey

Time allowed: *Two* hours.  
Attempt *four* questions.

1. Outline the main sources and characteristics associated with hazardous and clinical wastes. Also discuss the various treatments and disposal options available for each of the above type of waste.

[20]

2. (a) Dioxins and furans are found in the emission gases from the incineration of various waste types. Argue the cases for and against human health hazards associated with these compounds and refer to possible adverse effects .

[10]

- (b) The ultimate analysis of a sample of municipal solid waste gives the following results:

<i>Element / Compound</i>	<i>Weight %</i>
C	30
H	4
O	20
N	0.6
S	0.1
H <sub>2</sub> O	21
Others	24.3

Determine the moles of air required for incineration and the mole and weight percentages of carbon dioxide and nitrogen in the flue gases.

[10]

- 3 (a) Briefly describe the main liner materials used to contain landfill leachate; make reference to characteristics, advantages and construction procedures.

[8]

- (b) A municipal solid waste has the composition and moisture content as shown in the following table.

	Composition % by wt	Moisture (%)	Dry Solids* (g)
<b>Inert Materials</b>			
Glass	7	3	60
Ferrous metals	5	3	67
Nonferrous metals	1	3	25
Plastics	9	3	76
Rubber & leather	3	3	29
Others	2	4	23
<b>Decomposable</b>			
Paper, newsprint	39	7	300
Vegetable wastes	8	68	30
Grass, leaves etc	15	63	80
Textiles	5	13	40
Wood & bark	6	22	40

\* Dry Solids per kg of MSW.

Calculate the volume of methane generated by the anaerobic decomposition of the above waste if it has a volume at STP of 0.25 m<sup>3</sup>/kg.

Comment on the volume of waste calculated relative to expected values.

[12]

- 4 (a) Discuss how integrated waste management is applied to the management of wastes from different sources. In particular, refer to the integration of the six functional elements and their inter-relationships.

[10]

- (b) Describe the waste licensing procedures adopted by the EPA and outline the general requirements of the EPA before a license can be granted.

[10]

- 5 (a) Outline the principal waste legislation in Ireland. Indicate the roles of the organisations responsible for deciding and implementing waste legislation in Ireland.

[8]

- (b) Explain the importance of composting in the management of waste.

[6]

- (c) Describe the main factors and engineering requirements in the set-up of a composting facility.

[6]

- 6 (a) Mass transport of solutes in groundwater may be represented by the following equation for the one-dimensional case:

$$D_L \frac{\partial^2 C}{\partial x^2} - v_x \frac{\partial C}{\partial x} = R \frac{\partial C}{\partial t}$$

Identify each of the terms and explain the transport processes represented by the equation.

[13]

- (b) 'Containment' and 'bioremediation' are two of the methods commonly used to remediate contaminated soil and groundwater. Briefly describe each of these methods, indicating in what circumstances each one might be applied.

[7]

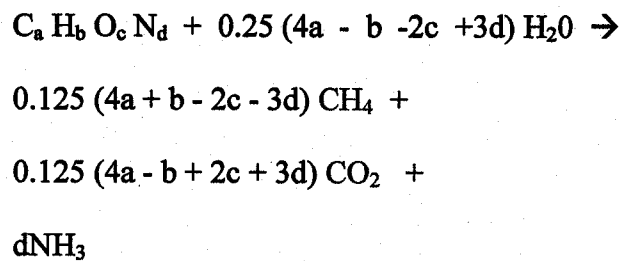
**ADDITIONAL INFORMATION**

Typical composition of air:-

<i>Carbon Dioxide</i>	0.03%
<i>Nitrogen</i>	78%
<i>Oxygen</i>	20.7%
<i>Water</i>	1.26%

Molecular weight of air 28.7

The anaerobic decomposition of MSW in landfill is given by following empirical formula:-



# PROXIMATE AND ELEMENTAL (ULTIMATE) ANALYSES AND HEATING VALUES OF REFUSE COMPONENTS

Refuse Component	Proximate Analysis (as-received) weight %				Elemental Analysis (dry) weight %					Higher Heating Value (kJ/kg)			
	Moisture	Volatile Matter	Fixed Carbon	Non-Comb.	C	H	O	N	S	Non-Comb.	As-Received	Dry	Moisture and Ash Free
<b>Paper and paper products</b>													
Paper, mixed	10.24	75.94	8.44	5.38	43.41	5.82	44.32	0.25	0.20	6.00	15800	17610	18730
Newsprint	5.97	81.12	11.48	1.43	49.14	6.10	43.03	0.05	0.16	1.52	18540	19720	20000
Brown paper	5.83	83.82	9.24	1.01	44.90	6.08	47.84	0.00	0.11	1.07	16870	17920	18140
Trade magazine	4.11	66.39	7.03	22.47	32.91	4.95	38.55	0.07	0.09	23.43	12220	12740	16630
Corrugated boxes	5.20	77.47	12.27	5.06	43.73	5.70	44.93	0.09	0.21	5.34	16380	17280	18260
Plastic-coated paper	4.71	84.20	8.45	2.64	45.30	6.17	45.50	0.18	0.08	2.77	17070	17910	18470
Waxed milk cartons	3.45	90.92	4.46	1.17	59.18	9.25	30.13	0.12	0.10	1.22	26340	27280	27650
Paper food cartons	6.11	75.59	11.80	6.50	44.74	6.10	41.92	0.15	0.16	6.93	16880	17980	19190
Junk mail	4.56	73.32	9.03	13.09	37.87	5.41	42.74	0.17	0.09	13.72	14160	14830	17210
<b>Food and food waste</b>													
Vegetable food waste	78.29	17.10	3.55	1.06	49.06	6.62	37.55	1.68	0.20	4.89	4174	19230	20230
Citrus rinds and seeds	78.70	16.55	4.01	0.74	47.96	5.68	41.67	1.11	0.12	3.46	3970	18640	19300
Meat scraps (cooked)	38.74	56.34	1.81	3.11	59.59	9.47	24.65	1.02	0.19	5.08	17730	28940	30490
Fried fats	0.00	97.64	2.36	0.00	73.14	11.54	14.82	0.43	0.07	0.00	38290	38290	38290
Mixed garbage I	72.00	20.26	3.26	4.48	44.99	6.43	28.78	3.30	0.52	16.00	5512	19730	23490
Mixed garbage II	—	—	—	—	41.72	5.75	27.62	2.97	0.25	21.87	—	16850	21540
<b>Trees, wood, brush, plants</b>													
Green logs	50.00	42.25	7.25	0.50	50.12	6.40	42.26	0.14	0.08	1.00	4890	9780	9880
Rotten timbers	26.80	55.01	16.13	2.06	52.3	5.5	39.0	0.2	1.2	2.8	10950	14810	15260
Demolition softwood	7.70	77.62	13.93	0.75	51.0	6.2	41.8	0.1	<0.1	0.8	16980	1810	18590
Waste hardwood	12.00	75.05	12.41	0.54	49.4	6.1	43.7	0.1	<0.1	0.6	14950	16980	17070
Furniture wood	6.00	80.92	11.74	1.34	49.7	6.1	42.6	0.1	<0.1	1.4	17090	18170	18470
Evergreen shrubs	69.00	25.18	5.01	0.81	48.51	6.54	40.44	1.71	0.19	2.61	6298	20310	20840
Balsam spruce	74.35	20.70	4.13	0.82	53.30	6.66	35.17	1.49	0.20	3.18	5691	22190	22910
Flowering plants	53.94	35.64	8.08	2.34	46.65	6.61	40.18	1.21	0.26	5.09	8598	18670	19670
Lawn grass I	75.24	18.64	4.50	1.62	46.18	5.96	36.43	4.46	0.42	6.55	4786	19330	20700
Lawn grass II	65.00	—	—	2.37	43.33	6.04	41.68	2.15	0.05	6.75	6256	17890	19190
Ripe leaves I	9.97	66.92	19.29	3.82	52.15	6.11	30.34	6.99	0.16	4.25	18570	20630	21580
Ripe leaves II	50.00	—	—	4.10	40.50	5.95	45.10	0.20	0.05	8.20	8221	16440	17910
Wood and bark	20.00	67.89	11.31	0.80	50.46	5.97	42.37	0.15	0.06	1.00	16050	20030	20230
Brush	40.00	—	—	5.00	42.52	5.90	41.20	2.00	0.05	8.33	11040	18370	20000
Mixed greens	62.00	26.74	6.32	4.94	40.31	5.84	39.00	2.00	0.05	13.00	6256	16460	18920
Grass, dirt, leaves	21-62	—	—	—	36.20	4.75	26.61	2.10	0.26	30.08	—	14610	20910
<b>Domestic wastes</b>													
Upholstery	6.9	75.96	14.52	2.62	47.1	6.1	43.6	0.3	<0.1	2.8	16190	17390	17880
Tires	1.02	64.92	27.51	6.55	79.1	6.8	5.9	0.1	1.5	6.6	32090	32340	34650
Leather	10.00	68.46	12.49	9.10	60.00	8.00	11.50	10.00	0.40	10.10	18510	20580	22910
Leather shoe	7.46	57.12	14.26	21.16	42.01	5.32	22.83	5.98	1.00	22.86	16840	18200	23610
Shoe heel and sole	1.15	67.03	2.08	29.74	53.22	7.09	7.76	0.50	1.34	30.09	25350	25640	36720
Rubber	1.20	83.98	4.94	9.88	77.65	10.35	—	—	2.00	10.00	26050	26350	29300
Mixed plastics	2.0	—	—	10.00	60.00	7.20	22.60	—	—	10.20	32790	33410	37210
Plastic film	3-20	—	—	—	67.21	9.72	15.62	0.46	0.07	6.72	—	32200	34580
Polyethylene	0.20	98.64	0.07	1.19	84.54	14.18	0.00	0.06	0.03	1.19	43460	45880	46510
Polystyrene	0.20	98.67	0.66	0.45	87.10	8.45	3.96	0.21	0.02	0.45	36180	38260	38400
Polyurethane (a)	0.20	87.12	8.30	4.38	63.27	6.26	17.65	5.99	0.02	4.38	26050	26110	27280
Polyvinyl chloride (b)	0.20	86.89	10.85	2.06	45.14	5.61	1.56	0.06	0.14	2.06	22680	22730	23260
Linoleum	2.10	64.50	6.80	26.80	48.06	5.34	18.70	0.10	0.40	27.40	18960	19330	26630
Rags	10.00	84.34	3.46	2.20	55.00	6.60	31.20	4.62	0.13	2.45	16050	17800	18240
Textiles	15-31	—	—	—	46.19	6.41	41.85	2.18	0.20	3.17	—	18690	19300
Oils, paints	0	—	—	16.30	66.65	9.65	5.20	2.00	—	16.30	31160	31160	37210
Vacuum cleaner dirt	5.47	55.68	8.51	30.34	35.69	4.73	20.08	6.26	1.15	32.09	14850	15710	23160
Household dirt	3.20	20.54	6.26	70.00	20.62	2.87	4.00	0.50	0.01	72.30	8535	8810	31740