GENERAL

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INTRODUCTION

Volume I of this Manual contains the procedures that are currently used by the Environmental Measurements Laboratory (EML). Volume II contains procedures currently not used at EML, but that are still valid and used at other laboratories. In any manual of this kind, it is necessary to set up certain conventions. Contained in this section are the units, abbreviations, and reagent and procedural conventions that are used in the various written methods.

UNITS AND ABBREVIATIONS

PREFIXES FOR UNITS IN THE INTERNATIONAL SYSTEM

exa	E	10^{18}	deci	d	10^{-1}
peta	P	10^{15}	centi	c	10^{-2}
tera	T	10^{12}	milli	m	10^{-3}
giga	G	10^{9}	micro	μ	10^{-6}
mega	M	10^{6}	nano	n	10^{-9}
kilo	k	10^{3}	pico	p	10^{-12}
hecto	h	10^{2}	femto	f	10^{-15}
deka	da	10^{1}	atto	a	10^{-18}

BASE UNITS OF THE INTERNATIONAL SYSTEM

Quantity	Name of unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mole	mol

UNITS OF LENGTH

Units		cm	m	km	inch	foot	mile
1 cm	=	1.	0.01	$1x10^{-5}$	0.39370	0.032808	$6.2137x10^{-6}$
1 m	=	100.	1.	0.001	39.3701	3.280840	$6.2137x10^{-4}$
1 km	=	$1x10^{5}$	1000.	1.	$3.937x10^{4}$	$3.281x10^{3}$	0.62137
1 in	=	2.54	0.0254	$2.54x10^{-5}$	1.	0.083333	$1.5783x10^{-5}$
1 ft	=	30.48	0.3048	$3.05x10^{-4}$	12.	1.	$1.8939x10^{-4}$
1 mile	=	$1.609x10^{5}$	$1.609x10^{3}$	1.609344	$6.336x10^{4}$	5280.	1.

UNITS OF AREA

Units		cm^2	m^2	ha	km^2	$foot^2$	$mile^2$
1 cm^2	=	1.	$1x10^{-4}$	$1x10^{-8}$	$1x10^{-10}$	$1.08x10^{-3}$	$3.861x10^{-11}$
1 m^2	=	$1x10^{4}$	1.	$1x10^{-4}$	$1x10^{-6}$	10.76391	$3.8610x10^{-7}$
1 ha	=	$1x10^{8}$	$1x10^{4}$	1.	0.01	$1.076x10^{5}$	$3.8610x10^{-3}$
1 km^2	=	$1x10^{10}$	$1x10^{6}$	100.	1.	$1.076x10^{7}$	0.3861022
1 ft^2	=	929.0304	0.0929030	$9.29x10^{-6}$	$9.29x10^{-8}$	1.	$3.5870x10^{-8}$
1 $mile^2$	=	$2.59x10^{10}$	$2.59x10^{6}$	258.9988	2.589988	$2.788x10^{7}$	1.

UNITS OF VOLUME

Units		cm^3	liter (L)	m^3	$inch^3$	$foot^3$	quart
1 cm^3	=	1.	$1x10^{-3}$	$1x10^{-6}$	0.0610237	$3.53x10^{-5}$	$1.0567x10^{-3}$
1 L	=	1000.	1.	$1x10^{-3}$	61.02374	0.0353147	1.056688
1 m^3	=	$1x10^{6}$	1000.	1.	$6.102x10^{4}$	35.31467	1056.688
1 in^3	=	16.38706	0.0163871	$1.64x10^{-5}$	1.	$5.79x10^{-4}$	0.01731602
1 ft^3	=	$2.832x10^{4}$	28.31685	0.0283168	1728.	1.	2.992208
1 qt	=	946.353	0.946353	$9.46x10^{-4}$	57.75	0.0342014	1.

UNITS OF MASS

Units		g	kg	ton (metric)	oz (avdp)	lb (avdp)	ton (avdp)
1 g	=	1.	$1x10^{-3}$	$1x10^{-6}$	0.0352740	$2.20x10^{-3}$	$1.1023x10^{-6}$
1 kg	=	1000.	1.	$1x10^{-3}$	35.27396	2.204623	$1.1023x10^{-3}$
1 metric ton	=	$1x10^{6}$	1000.	1.	$3.527x10^{4}$	2204.623	1.102311
1 oz	=	28.34952	0.0283495	$2.84x10^{-5}$	1.	0.0625	$3.125x10^{-5}$
1 lb	=	453.5924	0.4535924	$4.54x10^{-4}$	16.	1.	$5.x10^{-4}$
1 ton (avdp)	=	$9.072x10^{5}$	907.1847	0.9071847	$3.2x10^{4}$	2000.	1.

UNITS OF DENSITY

Units		g cm^{-3}	g L^{-1}	kg m^{-3}	oz in^{-3}	lb ft^{-3}	lb gal^{-1}
1 g cm^{-3}	=	1.	1000	1000	0.5780365	62.42795	8.345403
1 g L^{-1}	=	$1x10^{-3}$	1.	1.0	$5.780x10^{-4}$	0.06242795	$8.345x10^{-3}$
1 kg m^{-3}	=	$1x10^{-3}$	1.0	1.	$5.780x10^{-4}$	0.06242795	$8.345x10^{-3}$
1 oz in^{-3}	=	1.729994	1729.994	1729.994	1.	108.	14.4375
1 lb ft^{-3}	=	0.0160185	16.01847	16.01847	$9.259x10^{-3}$	1.	0.1336806
1 lb gal^{-1}	=	0.1198264	119.8264	119.8264	0.069264	7.480519	1.

UNITS OF PRESSURE

Units		Pascal	dyn cm^{-2}	bar	atm	mm Hg (torr)	in Hg
1 Pascal	=	1.	10	$1x10^{-5}$	$9.869x10^{-6}$	$7.501x10^{-3}$	$2.953x10^{-4}$
1 dyn cm^{-2}	=	0.1	1.	$1x10^{-6}$	$9.869x10^{-7}$	$7.501x10^{-4}$	$2.953x10^{-5}$
1 bar	=	$1x10^{5}$	$1x10^{6}$	1.	0.9869233	750.0617	29.52999
1 atm	=	$1.013x10^{5}$	$1.013x10^{6}$	1.013250	1.	760.	29.92126
1 mm Hg	=	133.3224	1333.224	$1.333x10^{-3}$	$1.316x10^{-3}$	1.	0.039370
1 in Hg	=	3386.388	$3.386x10^{4}$	0.0338639	0.03342105	25.4	1.

UNITS OF ENERGY

Units		International Joule	cal_{IT}	Btu_{IT}	kWh	hp hr	L-atm
1 int J	=	1.	0.2388853	9.48×10^{-4}	2.78×10^{-7}	3.73×10^{-7}	9.871×10^{-3}
1 cal_{IT}	=	4.186109	1.	3.97×10^{-3}	1.16×10^{-6}	1.56×10^{-6}	0.0413205
1 Btu_{IT}	=	1054.882	251.9958	1.	2.93×10^{-4}	3.93×10^{-4}	10.41259
1 kWh	=	3.599×10^{6}	8.598×10^{5}	3412.142	1.	1.341022	3.5529×10^{4}
1 hp h	=	2.684×10^{6}	6.412×10^{5}	2544.33	0.7456998	1.	2.6494×10^{4}
1 L-atm	=	101.3083	24.20106	0.0960376	2.81×10^{-5}	3.77×10^{-5}	1.

UNITS OF RADIOACTIVITY

Units		becquerel (Bq)	disint./minute (dpm)	Curie (Ci)	picoCurie (pCi)
1 Bq	=	1.	60.	2.70×10^{-11}	27.
1 dpm	=	0.01667	1.	4.5×10^{-13}	0.450
1 Ci	=	3.7×10^{10}	2.22×10^{12}	1.	1.0×10^{12}
1 pCi	=	0.037	2.22	1.0×10^{-12}	1.

UNITS OF RADIATION EXPOSURE

Units		roentgen (R)	coulombs/kilogram ($C\ kg^{-1}$)
1 R	=	1	2.58×10^{-4}
1 $C\ kg^{-1}$	=	3876	1

UNITS OF ABSORBED DOSE

Units		gray (Gy)	joule/kilogram ($J\ kg^{-1}$)	rad
1 Gy	=	1	1	100
1 $J\ kg^{-1}$	=	1	1	100
1 rad	=	0.01	0.01	1

UNITS OF RADIATION DOSE EQUIVALENT

		Sievert	joule/kilogram ($J\ kg^{-1}$)	roentgen equivalent man (rem)
1 Sievert	=	1.	1.0	100.
1 $J\ kg^{-1}$	=	1.0	1.	100.
1 rem	=	0.01	0.01	1.

THE CHEMICAL ELEMENTS

Element	Symbol	Atomic Number	Atomic Weight	Element	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227.028	Mendelevium	Md	101	(258.)
Aluminum	Al	13	26.9815	Mercury	Hg	80	200.59
Americium	Am	95	(243.)	Molybdenum	Mo	42	95.94
Antimony	Sb	51	121.75	Neodymium	Nd	60	144.24
Argon	Ar	18	39.948	Neon	Ne	10	20.179
Arsenic	As	33	74.9216	Neptunium	Np	93	237.048
Astatine	At	85	(210.)	Nickel	Ni	28	58.69
Barium	Ba	56	137.33	Niobium	Nb	41	92.9064
Berkelium	Bk	97	(247.)	Nitrogen	N	7	14.0067
Beryllium	Be	4	9.01218	Nobelium	No	102	(259.)
Bismuth	Bi	83	208.980	Osmium	Os	76	190.2
Boron	B	5	10.81	Oxygen	O	8	15.9994
Bromine	Br	35	79.904	Palladium	Pd	46	106.42
Cadmium	Cd	48	112.41	Phosphorus	P	15	30.9738
Calcium	Ca	20	40.08	Platinum	Pt	78	195.08
Californium	Cf	98	(251.)	Plutonium	Pu	94	(244.)
Carbon	C	6	12.011	Polonium	Po	84	(209.)
Cerium	Ce	58	140.12	Potassium	K	19	39.0938
Cesium	Cs	55	132.905	Praseodymium	Pr	591	40.908
Chlorine	Cl	17	35.453	Promethium	Pm	61	(145.)
Chromium	Cr	24	51.996	Protactinium	Pa	91	231.036
Cobalt	Co	27	58.9332	Radium	Ra	88	226.025
Copper	Cu	29	63.546	Radon	Rn	86	(222.)
Curium	Cm	96	(247.)	Rhenium	Re	75	186.207
Dysprosium	Dy	66	162.50	Rhodium	Rh	45	102.906
Einsteinium	Es	99	(252.)	Rubidium	Rb	37	85.4678
Erbium	Er	68	167.26	Ruthenium	Ru	44	101.07
Europium	Eu	63	151.96	Samarium	Sm	62	150.36
Fermium	Fm	100	(257.)	Scandium	Sc	21	44.9559
Fluorine	F	9	18.9984	Selenium	Se	34	78.96
Francium	Fr	87	(223.)	Silicon	Si	14	28.0855
Gadolinium	Gd	64	157.25	Silver	Ag	47	107.868
Gallium	Ga	31	69.72	Sodium	Na	11	22.9898
Germanium	Ge	32	72.59	Strontium	Sr	38	87.62
Gold	Au	79	196.967	Sulfur	S	16	32.06
Hafnium	Hf	72	178.49	Tantalum	Ta	73	180.948
Helium	He	2	4.00260	Technetium	Tc	43	(98.)
Holmium	Ho	67	164.930	Tellurium	Te	52	127.60
Hydrogen	H	1	1.00794	Terbium	Tb	65	158.925
Indium	In	49	114.82	Thallium	Tl	81	204.383
Iodine	I	53	126.905	Thulium	Tm	69	168.934
Iridium	Ir	77	192.22	Thorium	Th	90	232.038
Iron	Fe	26	55.847	Tin	Sn	50	118.71
Krypton	Kr	36	83.80	Titanium	Ti	22	47.88
Lanthanum	La	57	138.906	Tungsten	W	74	183.85
Lawrencium	Lr	103	(260.)	Uranium	U	92	238.029
"	Lw	"	"	Vanadium	V	23	50.9415
Lead	Pb	82	207.2	Xenon	Xe	54	131.29
Lithium	Li	3	6.941	Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.967	Yttrium	Y	39	88.9059
Magnesium	Mg	12	24.305	Zinc	Zn	30	65.39
Manganese	Mn	25	54.9380	Zirconium	Zr	40	91.224

GREEK ALPHABET

A,α	Alpha	H,η	Eta	N,ν	Nu	T,τ	Tau
B,ß	Beta	Θ,θ	Theta	X,χ	Xi	Y,υ	Upsilon
Γ,γ	Gamma	I,ι	Iota	O,o	Omicron	Φ,ϕ	Phi
Δ,δ	Delta	K,κ	Kappa	Π,π	Pi	X,χ	Chi
E,ϵ	Epsilon	Λ,λ	Lamba	P,ρ	Rho	Ψ,ψ	Psi
Z,ζ	Zeta	M,μ	Mu	Σ,σ	Sigma	Ω,ω	Omega

CHEMICAL CONVENTIONS

1. The commercial concentrated acids and ammonium hydroxide are indicated by the chemical symbol only.

2. "Water" or "H_2O" refers to distilled water or deionized water. Special requirements are noted in the procedures.

3. Diluted acids are usually given as parts of acid to be added to parts of water. Thus 1:9 means one part of concentrated acid plus 9 parts of water by volume. In a few procedures, normality (N) or molarity (M) values are given.

4. All concentrations or dilutions are approximate, unless stated as exact or that preparation or dilution in a volumetric flask is required.

5. Carrier concentrations are given in the reagent list for each procedure. In the procedures, all additions of carrier are made by volume with a pipet. Carrier solutions must be standardized if recovery values are to be determined gravimetrically.

6. Approximate tracer concentrations are given in the reagent list for each procedure. The addition of tracer is usually made by weight, and the tracer "standardization" is made with each batch of samples.

7. The conventions used for pH determination are that wide-range pH papers may be used for obtaining the pH indicated unless measurements with narrow range paper or a pH meter are specifically mentioned.

8. It is considered that good analytical and laboratory safety practices will be followed in all work: that the apparatus is clean, that all transfers are quantitative and that all precipitates are washed carefully. Where qualifications appear, they indicate that extra care is required.

CONCENTRATIONS OF COMMON ACIDS AND BASES

Name and Formula	Specific Gravity	Percent	Molarity	Normality
Hydrofluoric acid, HF	1.17	48	28	28
Hydrochloric acid, HCl	1.18	37	12	12
Perchloric acid, $HClO_4$	1.5-1.6	60	10	10
Nitric acid, HNO_3	1.42	70	16	16
Nitric acid, HNO_3 fuming	1.49	90	21	21
Sulfuric acid, H_2SO_4	1.84	96	18	36
Phosphoric acid, H_3PO_4	1.70	85	15	45
Acetic acid, $HC_2H_3O_2$ glacial	1.05	99.5	17	17
Ammonium hydroxide, NH_4OH	0.90	27 (NH_3)	14	14

INDICATORS

Acid-Base Indicators

Indicator	Type	Acidic Color	Basic Color	pH Range
Bromocresol Green	Acid	Yellow	Blue	3.8-5.4
Bromthymol Blue	Acid	Yellow	Blue	6.0-7.6
Cresol Purple	Acid	Yellow	Purple	7.4-9.0
Phenolphthalein	Acid	Colorless	Red-Violet	8.5-10.0
Thymol Blue	Acid	Red	Yellow	1.2-2.8
Thymolphthalein	Acid	Colorless	Blue	9.3-10.5
Methyl Orange	Base	Red	Yellow	3.1-4.4
Methyl Red	Base	Red	Yellow	4.2-6.2
Tropeoline OO	Base	Red	Yellow	1.3-3.0

Reduction Indicators

Indicator	Color of Reduced Form	Color of Oxidized Form
Orthophenanthroline Ferrous	Red	Pale Blue
Diphenylamine Sulfonate	Colorless	Violet
Starch-Iodine-Iodide	Colorless	Blue
Indigo Sulfonates	Colorless	Blue

JULIAN DATE CALENDAR (for leap years only)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

JULIAN DATE CALENDAR (perpetual)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31