

Index

A

Absorbents/absorbency Amberlite® polymeric resins, chemical hood filters, 196, 231 gloves, 176 spill containment, 28, 120, 125, 133, 134, 145, 177, 302 waste management, 193, 203, Absorption in the body (see also Exposure) gastrointestinal tract, 58 prevention, 124, 179 radiation, 81 respiratory tract, 57, 124, 166, skin, 55, 58, 60, 62, 124, 139, 166, 179 Academic laboratories Chemical Hygiene Officer, 16 chemical hygiene responsibilities, 16-17, 187 culture of safety, 2, 3-4, 5, 6 department chairperson or director, 16-17 departmental safety committee, 17 facilities, maintenance, and custodial personnel, 17 high school laboratories, 3 laboratory personnel, 17, 187 laboratory supervisor, 17 liability concerns, 6 management of chemicals, 88, 93, 102, 296-297 recordkeeping, 3 regulations for, 194 research laboratories, 4 training program, 250 undergraduate laboratories, ventilation design, 251 waste management, 3, 186-187,

Access control, 20, 22, 28, 29, 92, 95, 101, 123-124, 126, 163, 206, 208, 214, 256, 257, 262, 263, 264, 301, 302 Accidents (see also Emergency; Fire; Injuries and illnesses; Safety and emergency equipment; Spills and releases) CHP component, 295, 299, 300, 302, 303 costs of, 6 equipment-related, 149, 150, 151, 153 liability consequences, 6, 102, 116 misuse of materials, 7 MSDS information, 50 plant-scale, 139 preparation for, 107, 110, 125, 130, 150, 153, 158, 160, 299 prevention, 16-17, 21, 86, 87, 95, 110, 113, 140, 141, 150, 151, 155, 216, 302 regulations, 272, 281, 299 reporting and record keeping, 5, 16, 19, 29, 30, 181, 281, 299 reviews, 3, 17 slips, trips, and falls, 77, 150, 164 vehicular, 102, 193 working alone and, 17 Acetaldehyde, 67, 72, CD Acetic acid, 67, 68, 72, 96, 134, 136, 189, 202, 203, 204, CD Acetone control banding, 64 -dry ice coolant, 173 dual-use hazard, 260 flammability, 65, 67, 68, 120, 173 inhalation, 57 LCSS, CD spills, 48 storage of chemical in, 135 waste management, 85, 190

Acetyl peroxide, 303 Acetonitrile, 67, 69, 160, 204, CD 2-Acetylaminofluorene, 273 Acetylene and acetylenic compounds, 62, 69, 71, 72, 129, 135, 140, 166, 172, CD Acetylides, 70, 71, 130 ACGIH (see American Conference of Governmental Industrial Hygienists) Acid baths, 220 Acid inhibitors, 70 Acids (see also specific compounds) allergic response to, 61 chemical hoods and exhaust systems, 139, 214, 224, 226, 233-234, 236, 240, 242, 254 cleaning with, 73, 86, 138, 139-140 corrosivity, 190, 245 decontamination concerns, 254 digestion bombs for microwaves, 159 dilution/dilute, 17, 137, 138, 140, 189, 209 drying with, 140 emergency procedures, 118, 120, 180 in environmental rooms, 245 equipment for use with, 88 explosion hazards, 70, 71, 96, 130, 131, 136, 139-140, 214, fire hazards, 67, 68, 69, 98, 99, 128-129 gloves and protective clothing, incompatibilities, 70, 73, 96, 98, 100, 128-129, 138, 139 injuries, 58, 61, 118, 137, 138, 180, 214, 260 labels/classification, 69 neutralization of, 120, 137, 138, 195, 196, 209 neutralization with, 121, 136, 208

194, 196, 201

oxidizers, 69, 73, 96, 98, 120, 128-129, 131, 138, 188	oven drying of samples, 156-157	Air (see also Hot air; Respirators; Ventilation and
peroxidizables, 72, 134, 139	"particularly hazardous	environmental control
radioactive mixtures, 202, 203,	substances," 55, 59, 274-275	systems)
205	risk assessment, 54, 55, 59-60	autooxidation, 136
rules for working with, 301	signs and symptoms, 19, 123,	cleanliness in clean rooms, 244
scrubbers, 236	137, 141	compressed, 145, 165, 171,
spills, 28, 120	storage of chemicals, 97, 101	180-181
storage, 20, 96, 97, 98, 99, 100, 125	systemic effects, 59	dispersion modeling, 124
testing with, 188, 189	waste regulation, 277	filters, 124, 126, 142, 143, 178,
waste management, 196, 202,	Administration and supervision	179, 221, 236
203, 204, 205, 209, 210, 301	(see also Chemical Hygiene	liquefied, 69, 135, 138
Acquisition of chemicals	Officers; Chemical Hygiene	motors, 151, 154
CHP component, 295, 297, 298	Plan; Documentation and	pollutants, 86, 234, 235-236
compressed gases, 89, 140,	record keeping; Inspections	pressure control, 214, 219, 240
164-165	and audits)	reactivity in, 70, 72, 87, 93, 125,
computerized, 88, 89	chemical hygiene	130, 134, 135, 136, 137, 139,
controlled substances, 261	responsibilities, 15, 16, 17,	140, 141, 143, 160, 173
cost containment, 5, 92	18, 22, 24, 297, 298-299	showers, 244
donations and gifts, 87, 92		
<u> </u>	and culture of safety, 2, 3, 5, 7	supply, 179, 180-181, 217, 222,
just-in-time deliveries, 43, 89	emergency preparedness, 39, 42, 117, 178, 180, 281, 299	226, 227, 241
minimization, 5, 21, 84, 164,		Airborne contaminants (see also
186	hazard controls, 14, 18, 19, 24,	Exhaust systems; Filters and
monitoring, 16, 19	108, 142	filtration)
ordering, 21, 86, 88-89	hazard evaluation and risk	action levels, 269
receiving, 21, 79, 89-90, 263,	assessment, 47, 55, 60, 66,	in chemical hoods, 291
278, 299	75, 108, 123, 131, 301	dry materials, 144
in smaller containers, 86	laboratory supervisor, 17, 22,	evaluating exposure, 209
standards for, 21, 22, 278, 299	24, 26, 75, 117, 177, 178, 180,	explosive limits, 65, 66-67
Acrolein, 60, 70, 303, CD	231, 297-298, 299	lethal (LC) values, 56
Acrylamide, CD	management of chemicals, 84,	monitoring, 60, 143, 144, 208,
Acrylonitrile, 112, 273, 303, CD	123, 173	228, 298
Action levels, 16, 123, 269, 289,	OSHA recommendations for,	nanoparticles in, 135, 143, 144,
292, 293-294	296-300	248
Activated carbon, 73, 136, 204,	reporting to supervisors, 15,	particulate materials, 57
231, 236	16, 17, 226, 301	pressure buildup and, 135
Acute toxicity (see also Allergens,	security, 123, 145, 262	preventing exposure, 107, 178,
sensitizers, and allergic	statutory requirements, 279,	219, 296
reactions; Corrosives and	280, 281, 295	protection against, 127, 144,
corrosivity; Irritants)	waste management, 209, 302	178-180
aquatic, 50	Adverse reactions, 271, 279	risk assessment, 219
defined, 59	Aerosols	skin exposure, 179
dose-response relationships, 54	biological hazards, 60, 126, 221	threshold limits, 60
employee protection standards,	defined, 57	vapor pressure and, 57
274, 275, 290, 293, 295,	in environmental rooms, 245	ventilation systems and, 219,
301-302	filters and scrubbers, 124, 236,	221, 241, 251, 296, 298
empty containers, 191	301, 302-303	ALARA (as low as reasonably
examples of highly toxic	flammable, 50, 99, 290	achievable) principle, 82,
compounds, 56, 60, 275, 301	housekeeping and, 114	219, 221
exposure factors, 60	inhalation, 57-58, 110, 221	Alarms
information sources, 48, 50, 51,	monitoring, 144	audibility in environmental
59	radioactive, 204, 208, 221	rooms, 245, 299
lethal dose/lethal	risk assessment, 55, 60, 80, 221	building code requirements,
concentration, 54-55, 59, 60,	suppression, 114, 124, 126, 208,	218
275	236, 240, 244, 301, 302-303	in chemical hoods, 169, 226, 250

equipment, 216 fire, 15, 27, 28, 43, 107, 117, 121, 122, 127, 166, 176-177, 178, 217, 245, 249, 299 gas detectors, 137, 168, 169, 2 heat sensors and smoke detectors, 100, 178, 249 low-oxygen, 163, 173 security, 124, 256, 258, 264 signage and postings for, 250 spills and releases, 35, 82, 124 testing/inspection, 43, 193, 245, 249, 250 Alcohols (see also specific compounds) consumable, 95, 245 denatured, 259 disinfection with, 247 flammability, 99 incompatibilities, 73, 130, 139 secondary, 72 shipment of samples in, 101 in thermometers, 88 Aldehydes, 210 Aliphatic hydrocarbons, 133 Alkali metals, 59, 70, 73, 128, 130-131, 140, 178, 190, 210 Alkalis and bases explosive hazards, 69, 70, 73, 130-131, 190 fire control, 140, 178 incompatibilities, 73, 128 injuries, 58 neutralization, 120, 209, 210 spills, 120 waste management, 209, 210 Alkenes, 72, 135 Alkyl chloromethyl ethers, 63-64 Alkyl nitrites, 71 Alkyl perchlorates, 71 Alkylating agents, 64 Alkylbenzenes, 203 Alkylhydroperoxides, 71 Alkyllithium compounds, 96, 135-136 Allergens, sensitizers, and allergic reactions, 16, 58, 59, 60-61, 279, 295, 301 Allylic halides, 61, 72 Alumina, 136, 160, 236 Aluminum chloride, see Aluminum trichloride Aluminum trichloride, 136, CD

Amberlite® polymeric resins, 204

American Biological Safety Association, 80 American Chemical Society, 17, 53, 86, 109, 116, 218, 262, 267, 274 American Chemistry Council, 267 American Conference of Governmental Industrial Hygienists (ACGIH), 267, 297 exposure limits, 48, 86 ventilation manual, 239 American Heart Association, 180 American Industrial Hygiene Association, 267, 269 American Institute of Chemical Engineers, 267 American National Standards Institute, 48, 108, 162, 217, 253, 269, 270 American Society of Heating, Refrigeration, and Air Conditioning Engineers, 253, 273 American Society of Mechanical **Engineers** Boiler and Pressure Vessel Code, 170-171 Americans with Disabilities Act, 6, 218, 272 Aminechromium peroxocomplexes, 71 Ammonia, 57, 61, 69, 121, 129, 136, 141, 164, 166, 170, 260, 270, 303, CD Ammonium hydroxide, 71, 96, CD Ammonium nitrate, 69, CD Ammonium phosphate extinguishers, 178-179 Anaphylactic shock, 61, 112 Anhydrides, 61, 115, 210 Aniline, 303, CD Animal and Plant Health Inspection Service, 205, 260, 270, 273 Animals (see Laboratory animals; Service animals) Annual Report on Carcinogens, 63, 291, 304 Anosmia, 60 ANSI (see American National Standards Institute) ANSI/ASHRAE standards, 221,

222, 225, 227, 231, 249

Aprons, 15, 113, 138, 175 Aqueous solutions acids, 121 bleach, 206 corrosives, 61, 121 hydrogen fluoride, 137 hydroxides, 61, 139 pH testing, 188, 189 plastic equipment for, 168 potassium iodide, 134, 189 reducing agents for peroxides, waste management, 107, 185, 190, 192, 195, 196, 202, 203, 204-205, 206, 207 Argon, 62, 130, 131, 134, 135, 159, 160, 161, 172, 174, 234 Armored chemical hoods, 132 mercury thermometers, 88 Aromatic hydrocarbons, 63, 133 Arsine, 60, 239, CD Asbestos, 57, 141, 179, 273 Ascarite[®], 136 ASHRAE (see American Society of Heating, Refrigeration, and Air Conditioning Engineers; ANSI/ASHRAE standards) Asphyxiants and asphyxiation, 62, 74, 90, 100, 140, 163, 168, 172, 173, 178, 242, 245 Aspirators, 75, 110, 153, 174 Assembly point, emergency, 39, 193 Atomic absorption spectrophotometers, 121, 237, 254 Atomic Energy Act, 202, 271 Audits (see Inspections and audits) Autoclaves and autoclaving, 171 animal carcasses, 208 canopy hood, 239 contaminated labware, 206 dedicated rooms or equipment, 208, 215 headspace, 166 hydrogenation reactions, 135 infectious waste, 206 multihazardous waste, 205, 206, 207, 208 pressurization, 135, 166, 172 testing for interior surface contamination, 208 thermometer, 88

Autoignition, 65-66, 69, 73, 130, risk assessment, 13, 79, 80, 207, Calcium, 130 135, 136, 139, 140, 141, 156 Calcium gluconate gel, 138 Autoxidation, 72, 73, 136 security, 256, 260, 262, 263, 264 Calcium oxide, 61, 70 Azides, 60, 70-71, 96, 130, 136, select agents, 79, 270 Calorimetry, 131 210, 260, 303, CD shipping, export, and import, Cancer, 51, 59, 63, 64, 82, 101 (see 101, 272, 278, 280-281 Azo compounds, 72, 273 also Carcinogens) storage, 97 Canopy hoods, 220, 237, 239, 247, synthetic microorganisms, 79 298 В Capacitors, 76, 150, 152, 153 waste management, 87, 108, 127, 185, 187, 189, 195, 201, Carbon-14, 81 Back injuries, 77 Bar code labeling, 19, 91 202, 205-208, 278 Carbon brushes, 151 Barriers and barricades, 74, 82, Biosafety cabinets (BSCs), 75, 80, Carbon dioxide, 62, 86, 132, 135, 108, 110, 120, 123, 125, 131, 126, 143, 220, 221, 231, 236, 138, 140, 170, 173, 177, 178, 132, 137, 151, 213, 223, 224, 244, 245-248, 251 205, 245, 252 Biosafety in Microbiological and 229, 252, 256, 258 Carbon disulfide, 56, 62, 66, 67, Bases (see Alkalis and bases) Biomedical Laboratories, 79, 69, 128, 129, 136, 303, CD Benchtop 80, 126, 189, 246, 260, 276 Carbon inventory, 251 ventilated enclosures, 143, 220, Biosafety levels, 80, 126 Carbon monoxide, 56, 62, 63, 69, 129, 166, 179, 303, CD 228, 240 Birth defects (see Developmental Benzene, 57, 63, 65, 86, 96, 190, toxicity) Carbon powder, 73, 131, 136 273, 303, CD Bis(chloromethyl)ether, 54, 273, Carbon steel, 174 Benzyl azides, 96 Carbon tetrachloride, 137, 140, Blankets, 36, 119, 121, 122, 180 Benzyl halides, 61 178, 303, CD Benzylamine, 96 Boiling chips, 73 Carbonyls, 166, 302, 303 Benzylic hydrogens, 72 Boiling eruptions, 73 Carcinogens Boiling points, 48, 65, 67, 68, 73, Benzyltrimethylammonium clothing and protective hydroxide, 96 86, 99, 139, 172 apparel, 113 Biodegradation and Boron halides, 136 combinations of compounds, biodegradable materials, 88, Boron trichloride, 140, 303 196, 203 Boron trifluoride, 140, 170, 303, defined, 63, 275, 291-292 Biological materials and CDexamples, 54, 63, 302 biohazards Bourdon tubes, 167 experiment planning, 64 Bretherick's Handbook of Reactive exposure factors, 56, 64 aerosols, 60, 126, 221 animal tissues and carcasses, Chemical Hazards, 52, 65, 304 information resources, 48, 50, 205, 206, 207-208, 303 Bromine, 61, 62, 303, CD 52, 53, 63, 291, 304 biosafety levels, 80, 126, 126 Building code requirements, 11, labeling, 101 Chemical Hygiene Plan, 15 22, 27, 95, 98, 100, 215, 217, LCSS information, 63 218, 242, 253, 272-273 containment and biosafety minimizing/avoiding facilities, 75, 80, 126, 143, Bulk materials, 77, 78, 87, 89, 94, exposure, 55, 64, 86, 274 220, 221, 231, 236, 243, 244, 107, 133, 141, 142, 145, 195, MSDS information, 48 radiation, 75 245-248, 251 198, 236 disinfection and Bunsen burners, 27, 69, 128 risk assessment, 54, 55, 63-64 decontamination, 206, 254 Bunsen tube, 172 select carcinogens, 55, 59, Burns, 19, 28, 58, 59, 61, 66, 75, 63-64, 86, 97, 274-275, 290, dual-use agents, 256 exposure limits, 51 113, 118, 119, 122, 136, 137, 291-292 138, 139, 141, 149, 161, 173, filters, 236 spills, 273 gloves and protective clothing, 214 standards for handling, 59, 63, 101, 273, 275, 290, 293, 302 tert-Butyl hydroperoxide, 303, CD information sources, 51, 79, 80, Butyllithiums, 135, 139, 140, CD storage, 97, 101 126, 189, 246, 260, 276 Card files, 91, 92 Carts, 6, 23, 77, 89, 90, 114, 153, procedures for working with, 126-127 168, 216 radioactive, 207-208 Cabinets (see Biosafety cabinets; Casarett and Doull's Toxicology: The regulation, 79, 189, 270-271, Storage) Basic Science of Poisons, 52 272, 276, 278, 280-281 Cadmium, 273 Catalog of Teratogenic Agents, 52, 62

Catalysts, 70, 72, 73, 74, 78, 130, container size and fill level, 23 benchtop, 232 135, 136-137, 139, 160, 210 determining regulatory status, bypass, 230 California chemical fume 190-191 Cathode ray tubes, 163 Cathodes, 75 empty containers, 191 hood, 233 Caustics, 28, 58, 111, 120, 196 gases, 198 in clean rooms, 234, 244 at generation site, 191-192 compressed gas cylinders in, (see also Corrosives and generator types and corrosivity) Celite, 84 definitions, 276 configurations, 232-234 constant air volume, 229-230 Centers for Disease Control and hazard reduction in-laboratory, Prevention, 77, 111, 205, 207, constant operation, 224-225 260, 270, 273, 276 identification responsibilities, distillation (knee-high or low-Centrifuges, 88, 161-162, 172, 216, boy), 229, 232, 233 incineration, 193, 195, 196, 197, 217 ductless, 231-232 Characterization of waste 199 energy conservation, 251, identification responsibilities, inspection, 26 187 labeling, 23 exhaust treatment and systems, for offsite management, liability concerns, 198-199 234-237, 241 186-187 limited waste, 190 explosion-proof, 248 test procedures for unknowns, manifesting, 199 exposure monitoring, 228 187-189 minimization, 277 design and construction, 229-232 unidentified materials minimum requirements for face velocities, 221-222, 226-227 (unknowns), 187 generators, 277 Checklists monitoring offsite transport filters, 196, 220, 231, 232, 235, continuity of laboratory and management, 197-198 operations, 41 nonhazardous and general design recommendations, 229 emergency planning, 41 nonregulated waste inspection, 23, 25, 26, 27 managed as, 194-195 general rules, 15, 110 laboratory closeout, 253, CD housekeeping, 223 offsite management, 186-187, laboratory hazard assessment, 197-198 instrumentation, 228 "on-site" definition, 276-277 liquid scrubbers, 235-236 CD low-flow or high-performance, security vulnerability, 262 preparation for shipment, Chemical Abstracts Service 231, 251 (CAS), 52-53 maximizing efficiency, 222-223 records and recordkeeping, registry numbers, 87, 91, 94 nonbypass, 229-230 199-201 regulation, 189-191, 194, 271, perchloric acid, 233-234 Chemical Carcinogenesis Research Information 276-278 performance-related factors, System, 53 sanitary sewer disposal, 196 test procedures, 187-189 proximity to windows and Chemical Facility Anti-Terrorism Standards (CFATS), 89, 259, transportation of, 277-278 doors, 222 261, 270, 273 treatment and recycling, radioisotope hoods, 234 Chemical hazardous waste 196-197 sashes, 223-224, 252 unidentified materials scrubbers and contaminant academic laboratories, 186-187, (unknowns), 187-189 removal systems, 235 194, 196, 201 acids, 196, 202, 203, 204, 205, Chemical hoods (see also Exhaust shielding, 131-132, 160, 177, 209, 210, 301 systems) alkalis and bases, 209, 210 acid use in, 139, 214, 224, 226, supply air diffuser proximity, 233-234, 236, 240, 242, 254 assignment of tasks for 222 testing and verification, handling, 194 adsorbents, 236 225-228 atmospheric disposal, 196 airborne contaminants, 291 thermal oxidizers and central area for, 192-194 airflow types, 229-232 characteristic waste, 189-190 airfoils and baffles, 229 incinerators, 237 characterization, 186-189 alarms, 169, 226, 250 traffic proximity, 222 variable air volume, 230, 252 choosing transporter and alternatives to, 252 walk-in, 232-233 disposal facility, 198 armored, 132 collection and storage, 191-194 auxiliary air, 230-231 and waste disposal, 222

Chemical Hygiene Officers Children, 16 Clinical and Laboratory (CHOs), 2-3, 15, 16, 18, 20, Chlorinated hydrocarbons, 63, Standards Institute, 269 21, 22, 23, 26, 27, 28 n.4, 47, Clinical laboratories, 79, 201, 202, 51, 63, 79, 114, 274, 289, 290, Chlorine, 60, 61, 69, 70, 136, 170, 205, 269, 276, 281 295, 297 260, 303, CD Closure or loss of institution Chemical Hygiene Plan (CHP) Chlorine dioxide, 75, 130, 136 or building (see also academic institutions, 16 Chlorine trifluoride, 140-141, 303 Decommissioning) access to, 19, 47, 293 Chloroform, 137, 202, 204, 205, alternative laboratory facilities, compliance with, 17, 19, 23 303, CD 42, 43 defined, 15, 289 1-Chloromethyl-4-fluoro-1,4checklist for continuity of development and diazoniabicyclo[2.2.2]octane operations, 41 implementation, 15, 16, 18, bis(tetrafluoroborate), 86 laboratory closeout checklist, 19, 20, 289, 292, 293, 295, Chloromethyl methyl ether, 63-64, CD 296, 303-305 273, CD long-term, 42 elements/topics, 3, 15, 47, 104, Chromates, 69, 73, 130, 210 short-term, 41-42 117, 222, 274, 275, 292-293, Chromatography/ Clothing and protective apparel 295, 296-305 chromatographs, 24, 69, 86, (see also Gloves and hand general principles for work 93, 113, 134, 192, 195, 216, protection; Personal with chemicals, 296-297 220, 237, 241 protective equipment) governmental laboratory, 20 Chromic acid, 86, 98, 99 aprons, 15, 113, 138, 175 guidance for development, Chromium, 61, 73, 138, 174, 205 choosing, 175 Chromium-51, 81 296-305 contaminated, 118, 122, 126, industry research facility, 18 Chromium trioxide and other 137, 144, 146, 175, 181, 300, information resources for chromium(VI) compounds, 301, 302 developing, 303-305 71, 86, 98, 99, 273, CD disposal, 113, 118, 144, 302 laboratory facility, 297-298 Chromosomal damage, 62, 275, entanglement in equipment, 291 153, 163 MSDSs, 303 OSHA Laboratory Standard, 3, Chronic exposure, 19, 56, 87 fires on, 122, 178, 180, 181 15, 47, 269, 274, 275, 292-293, Chronic toxicity and health footware, 120, 144, 175-176, 295, 296 effects, 11, 18, 19, 48, 50, 244, 300, 302 responsibility for chemical 51, 52, 56, 59, 62, 63, 87, jumpsuits, 175, 303 hygiene, 3, 51, 297 121, 123, 290, 295, 301, laboratory coats, 15, 19, 26, 109, 113, 126, 131, 132, 138, 144, review and update, 15, 19, 293 302 (see also Carcinogens; rules and procedures for Neurotoxicity; Reproductive 172, 214, 244, 247, 301, 303 working with chemicals, 61, toxins) laundering, 109, 113, 118, 144, Circuit boards, 94 300-303 175 safety recommendations, Circuit breakers and fuses, 28, 76, materials, 111-112, 132 120, 150, 151, 152, 153, 154, 303 for nanomaterials work, 143, training and communication 155, 162, 218 144 on, 17, 18, 29 Clean Air Act, 196, 278 radiation protection, 80, 127, Chemical management program Clean benches/laminar-flow (see Acquisition of hoods, 143, 219, 221, 239, static discharge from, 128 chemicals; Inventory and 248, 250 storage, 113, 175 tracking; Shipment and survival kit, 36 Clean rooms transport; Storage; Waste Cobalt, 61, 136 casework, furnishings, and management) fixtures, 216, 244 Cold baths, 173 Chemical properties (see chemical hoods, 234, 244 Cold burns, 66, 74, 119, 173 Laboratory Chemical classification, 243, 244 Cold rooms, 76, 97, 109, 152, 245, Safety Summaries; Material pressure control system, 219, 298, 299, 300 Safety Data Sheets; specific 243 Cold storage, 97-98 properties) protocols, 243-244 Cold traps, 75, 115, 151, 172, Chemicals of interest (COI), 23, Clean Water Act 173-174 89, 259, 260, 261, 262, 270, Cleaning (see Housekeeping and Color coding for identification, 275 cleaning) 100, 165

Combustion (see Explosive and highly reactive hazards; Fire; Flammability and flammable chemicals; Ignition sources and causes) Commingling of waste, 191, 193, 194, 198, 203 Communication during emergencies contact list, 38 e-mail, 38 emergency contacts for individual staff, 39 internet and blogs, 38-39 media and community relations, 39 plan for, 38-39 telephone, 38 text messages, 38 Comprehensive Guide to the Hazardous Properties of Chemical Substances, 51, 59 Compressed air, 145, 165, 171, 180-181 Compressed Gas Association (CGA) standards, 168, 169 Compressed gas cylinders (see also Pressure vessels and reactions) acquisition and returns, 89, 140, 164-165 in chemical hoods, 222 code requirements, 164, 168 fire extinguishers, 178 hazards, 19 inspection, testing, and records, 26, 27, 164, 165, 169, 170 labeling, 140, 165 leak prevention and control, 120-121, 140, 169, 170 lecture bottles, 89, 100, 165, 239 outlet connections, 168-169 outside location, 34 precautions for handling and use, 164-165, 168-170, 303 pressure-relief devices and regulators, 26, 164, 168, 169-170 securing and storing, 26, 35, 90, 96, 100, 111, 114, 154, 164, 166, 168, 170 transporting, 111, 114, 168 valves, 168, 169 venting, 168, 170

Compressed gases chemical hazards, 74, 140-141 compatibility, 96 corrosive, 121 defined, 164, 290 in environmental rooms, 245 flammable, 69-70, 74, 114, 120-121, 165, 170, 190 inert, 165 information sources, 15 in-house gas systems, 100, 140 inventory control, 140, 164 list of hazardous chemicals, 140-141 monitors and alarms, 169 oxidizing, 120-121, 170 physical hazards, 74, 291 procedures for working with, 140-141 regulations, 114, 164, 270, 290, 291 toxic gases, 96, 121 transferring, 166 Computer simulation of experiments, 5 Computer systems and services backup systems, 36, 259 cables and wiring, 216 checklist programs, 26 communication during emergencies, 38-39 EHS information services, 52-53 ergonomic considerations, 77, 216 face velocity testing, 227 facilities for, 213, 214, 216 fire extinguishers for, 177 information and data security, 258-259, 262 inventory and tracking, 22, 91 loss of data or systems, 36, 38 MSDSs, 47-48, 89 physical protection, 35 purchasing systems, 88, 89 viewing laser operations on, 75 Condensation, 69, 74, 92, 98, 133, 151, 152, 172, 173-174, 224, 225, 232 Condensers and condensing, 93, 115, 116, 130, 133, 135, 138, 149, 156, 172, 173, 174, 222,

232, 292

Confidential or Sensitive

Information, 259

Connectors, 115, 139, 156, 166, 167, 169 **Consumer Product Safety** Commission, 49 Contact lenses, 36, 109, 127, 301 Containers and packages (see also Compressed gas cylinders; Glass and glassware; Labels and labeling) accumulation containers, 209 on benchtops, 113 bulk and economy sizes, 21, 87, caps and seals, 154, 159, 192 corrosives, 137, 192 cyanide, 22 damaged or deteriorating, 90, 92, 114 dry ice in, 136 empty, 92, 94, 137, 190, 191, 198 flammable and combustible substances, 22, 23, 58, 69, 88, 98-99, 128, 129 gases, 102, 198 hazardous, 137, 191 headspace, 23, 73 for hydrogen fluoride, 137 inspection of, 22, 135 inventory and tracking, 91 metal, 69, 90, 128 in microwaves, 75-76, 159 for nanomaterials, 103, 143, 145 opening, 77, 100, 139 overpacks, 97 for peroxide formers, 21, 69, 133, 134 plastic, 99, 129, 145 recycling, 93-94, 191 in refrigerators, 154 regulatory standards, 21, 94, 103, 191, 194, 298, 301 remote handling, 132 secondary containment, 23, 98, 113, 114, 125, 145, 298, 301 securing, 95, 97 sharps disposal, 58, 111, 114, 206-207 small, 86-87 for storing chemicals, 35, 77, 89, 95, 96, 97, 98-99, 113, 114, transfers among, 23, 84, 87, 94, 104, 113, 123, 125, 240-241 transport, 6, 23, 89, 90, 114, 125, 298

unpacking and inspecting, 90 nonflammable, 74 donated materials from, 92 vented, 139-140 short-term storage and equipment, 163, 171 waste, 23, 58, 87, 93, 110, 111, conveyance, 175 hazard assessment, 253-254 transfer lines, 174 information sources, 253 114, 120, 125, 127, 144, 145, Culture of laboratory safety laboratories, 92, 93, 94 191, 192, 193, 194, 195, 198, academic laboratories, 3-4, 5 removal of hazards, 92, 253, 254 199, 206-207, 209 Contingency plans, 12, 15, 55, 66, accessibility for scientists with Decomposition, 70, 76, 87, 93, 130, 107, 125, 193, 197, 199, 302 disabilities, 6-7 133, 135, 136, 138, 139, 157, 166, 290, 292 Contractors, 4, 10, 12, 13, 14, 264, administration and Decontamination 281 supervision, 2, 3, 5, 7 Control banding, 64-65 of accident victims, 28, 29 communication and, 15 Controlled substances. 95, 261 authorized personnel, 29 continuous learning biosafety cabinets, 247-248 Convulsions, 119 environment, 14 Cooling baths, 76, 136, 149, 158, environmental impact, 5-6 in chemical hoods, 124 of chemical hoods, 234 170, 173 and federal funding, 6 Copper, 85, 133, 137, 138, 160, industrial and governmental devices, 75 165-166, 167, 174, 189 laboratories, 4-5 documentation, 253 legal and regulatory changes, 6 of equipment and glassware, Corrosives and corrosivity (see also specific classes and management commitment to, 124-125, 208, 302 chemicals) facilities for personnel, 143 operational excellence, 14 of gloves and other PPE, 112, classes, 61 containers for, 137, 192 oversight, 14 124, 176 responsibility and information sources on, 253, engineering controls, 220 equipment compatibility and accountability, 2-3, 4, 14 damage, 50, 76, 88, 165-166, security considerations, 7 of laboratories for 167, 170, 171, 174 technology and, 5, 6 decommissioning, 253, 254 tips for encouraging, 5 radiological, 127, 205, 208, 234, evacuation of systems, 153, 167 examples, 61, 73, 135, 137, 138, Custodial and maintenance 139, 140-141 personnel, 17, 25, 58, 110, regulatory standards, 275, 293, 120 n.3, 142, 177 n.3, 216, 300, 302 experiment planning, 61, 66 eye contact, 58, 61, 135, 141, 219, 245, 253, 268-269, 282 respiratory protective Cuts, 58, 76, 115, 118-119, 149, 164 equipment for, 178 Cutting and drilling tools and verifying, 121, 254 gases and gas leaks, 61, 121, 140-141, 165-166, 167, 170, operations, 16-17, 77, 78, of waste, 205, 206, 207, 208, 140, 143, 149, 152, 164 300, 302 172, 174 Cyanides, 22, 54, 56, 60, 62, 63, 70, of work surfaces and work gloves and protective apparel, 125, 166, 180, 187, 189, 190, areas, 27, 121, 124-125, 302 111, 113, 176 210, 260, 275, 301, 303 information sources, 52, 303 Dehydrating and drying agents, Cyanogen bromide, CD 61, 136, 138, 139, 140, 159, inhalation, 61 labeling, 69, 165, 192, 199 Cyanogen chloride, 260 160, 175 Cylinders (see Compressed gas neutralization, 209 Delivery (see also Receiving rooms and loading areas; Shipment PPE, 171-172, 176 cylinders) shipping and transport, 199 and transport) skin contact, 58, 61, 111, 135, service disruptions, 42 Department of Energy (DOE) 141, 190 storage, 97, 100, 166, 192, 221 Deactivation, 86, 127, 139, 160, exposure limits, 78, 82, 143 wastes, 153, 174, 190, 191, 192, **Integrated Safety Management** 199, 209 Decay in storage, 203-204, 207, System, 13-14 Cryogens 208, 278 nanomaterials guidelines, 77, 141, 142, 145 asphyxiation hazard, 163, 173 Decommissioning explosion hazard, 131 ANSI standard, 253, 254, 269 pollution prevention, 201 gases, 75, 90, 100, 173, 242 checklist, 253, CD Department of Homeland information sources, 52 cleaning and decontamination, Security (DHS), 23, 36-37, liquids, 19, 27, 74, 75, 76, 119, 254 89, 259, 261, 262, 263, 267, 135, 163, 170, 172-174, 176 clearance, 254 275

Department of Transportation Diethyl ether, 28, 65, 67, 68, 69, 72, containment, 128, 159, 174, 204 120, 128, 134, 136, 303, CD (DOT), 23, 49, 68, 90, 94, 98, explosive compounds, 109 99, 101, 102, 103-104, 116, Diethylamine, 67, 96, 302, 303 flammable/combustible 164, 172, 186, 190, 193, 197, Diethylene glycol dimethyl ether compounds, 159 198, 199, 267, 271, 277, 278, (diglyme), 72 heat guns and, 159 Diethylnitrosamine, 273, 302, 303, 279, 300 peroxide hazards, 72, 134, 136 Desiccators, 115, 140, 175 CD PPE, 174 Design of laboratory facilities Differential manometers, 88 radioactive solutions, 204 access control, 214-215 Differential scanning calorimetry, rotary flash evaporation, 204 accommodations for shutoff device, 159 individuals with disabilities, Differential thermal analysis, 131 solvent stills, 93, 159-160 6,218 Digital thermometers, 58 thermal, 160 adaptability, 215-216 Diisopropyl ether, 136 vacuum, 140, 153, 159, 174 casework, 216 Diisopropylfluorophosphate, 301, venting stills, 140, 153, 300 closed or separate laboratory waste, 195, 204 Diisopropylnaphthalene, 203 spaces, 214-215 Distilled water, 77, 157, 189 Dilution of Divinyl acetylene, 72 doors, 216 acids, 17, 137, 138, 140, 189, 209 equivalent linear feet of Documentation and record workspace, 215 bases, 209 keeping bleach, 206 academic laboratories, 3 flooring, 216 chemical hood effluent, 241, accidents, 5, 16, 19, 29, 30, 181, furnishings and fixtures, 216 layout, 215-216 242 281, 299 noise and vibration issues, flammable substances, 129, compressed gas cylinders, 26, 216-217 162, 228, 240 27, 164, 165, 169, 170 equipment, 42-43, 165, 167, older facilities, 218-219 high-energy reagents, 115 peroxides, 133, 134 170-171 open design, 213-214 safety equipment, 217-219 vapors and toxic gases, 129, exports and imports, 280 storage rooms, 22 162, 240, 242-243 waste management, 199-201 waste chemicals, 134, 196, 204, Donations and gifts of chemicals, utilities, 217-218 wet spaces relative to other 87, 92 spaces, 213 Dimethoxyethane, 120 Dose-response relationships, 54 Dimethyl sulfate, CD Downdraft hoods or tables, 220, windows and walls, 216 Designated areas, 22, 36, 39, 89, Dimethyl sulfoxide (DMSO), 58, 237, 239 101, 123, 125, 135, 145, 275, 67, 68, 136, CD Drains, 16, 28, 34, 114, 154, 180, 290, 293 217, 232, 233, 234, 235 (see 4-Dimethylaminoazobenzene, 273 Dimethylformamide, 204, CD also Sewer discharges) Detergents, 85, 86, 162, 191 Developmental toxicity, 52, 53, 2,5-Dimethylhexane, 72 Drills and exercises, 37, 43, 125, 55,62 Dimethylmercury, 29, 60, 302 259, 299 Dewar flasks, 74, 115, 133, 138, Dioxane, 72, 85, 134, 136, CD Dry benzoyl peroxide, 136 148, 172, 173, 174-175, 300 Diphosgene (trichloromethyl) Dry fire extinguishers and chloroformate, 85 sprinkler systems, 177, 178, Diaacetylene, 71 Diacyl peroxides, 71 Disabilities (see Scientists with Dialkyl peroxides, 71 disabilities) Dry ice, 40, 41, 77, 109, 133, 136, Diazomethane, 60, 61, 70, 72, 132, Disinfection, 79, 126, 127, 206, 140, 153, 164, 172, 173, 245 136, 301, CD 207, 208, 245, 247, 254 Dry nanoparticles, 78, 103, 142, Diborane, 60, 239, CD Disposal (see Waste management) 143, 144, 145, 248 1,2-Dibromo-3-chloropropane, Distillation Dry sand, 131 273 avoiding, 159 Dry sweeping, 114, 145, 302 chemical hoods and exhaust Dichloroacetylene, 140 Dry traps, 216 Dichloromethane (methylene systems, 229, 232, 233, 237, Dryboxes, 89, 132, 173 chloride), 57, 64, 136, 160, Drying column purification systems, 190, 273, CD with acids, 140 Dichromates, 69, 73, 301 160-161 agents, 61, 136, 138, 139, 140, Dicyclohexylcarbodiimide, 61 commercial recyclers, 185 159, 160, 175

gases, 136	as ignition sources, 21, 69, 76,	assembly point, 39
glassware, 17, 85, 156, 157,	128, 129, 149, 153, 154, 245	checklists, 41
159	inspection, 26	communications, 38-39
ignition hazards, 128, 136, 156,	instruments, 162	community-wide emergencies,
233	magnetic field hazards, 163	42
oven drying of samples, 151,	noise extremes, 164	data or computer systems, 36
156-157	outlet receptacles, 150	decision makers, with
radioactive waste, 204, 208	personal safety techniques, 152	succession, 37
solvents, 78, 140	precautions, 151-152	delivery and service
and spontaneous combustion,	rotating equipment and	disruptions, 42
73	moving parts, 163	drills and exercises, 43
train, 139	stirring and mixing devices,	equipment or materials losses,
Dual-use materials, 95, 256, 257,	154	36, 43
258, 259-260, 261, 262, 263	ultrasonicators, 161	essential knowledge and
Dusts (see Powders and dusts)	wiring, 26, 150-151 Electrical fires, 68, 76, 150, 177, 178	supplies, 36-37
	Electrical mes, 66, 76, 130, 177, 176 Electrical power interruption	essential personnel, 37-38 evacuations, 39
E	discontinuation of	fire, 34, 42-43
Earthquakes (see Seismic activity)	experiments, 40	flood, 34
Eating and drinking, 26, 109, 175,	dry ice, 41	general preparation, 117
300	environmental and storage	highly toxic materials, 125
ECOTOX, 53	conditions, 40	high-profile visitors, 35
Education and training in safety	generator power, 41	high-value or difficult-to-
practices	laboratory procedures, 40	replace equipment, 36
academic laboratories, 3-4	long-term, 40	impact/occurrence mapping,
case studies, 53	potential effects, 40	34
computer simulations, 5	preplanning, 40-41	institutional or building
and culture of safety, 2, 3, 4	security issues, 40	closure, 41-42
EHS management system, 12	short-term, 40	intentional acts of violence or
emergencies and spills, 34	UPS, 41	theft, 35-36
first aid, 16, 29, 37, 137, 138,	Electrochemical equipment, 149	leadership, 37-38
299	Electrocution and electric shock,	loss of laboratory, 42-43
hands-on, 4, 5, 29, 53, 121, 146	76	mission-critical equipment, 34,
informal, 4	Electromagnetic radiation	36
new employees, 29	hazards	outside responders and
radioisotope users, 13	laser light sources, 75, 162	resources, 43
regulatory requirements, 4	radio frequency and	pandemic-related, 35
risk assessment and, 53	microwave sources, 75-76,	political or controversial
student manuals, 4	162	researchers or research, 35
in teaching laboratories, 3-4	visible, ultraviolet, and	power loss, 40
topics, 29	infrared laser light sources,	preplanning, 33-37, 40-41, 43
Electrical equipment (see also	75, 162	priorities, 37
Distillation; Heaters	X-rays and electron beams,	records for replacement of
and heating equipment;	162-163	equipment, 42-43
Refrigerators and refrigeration; Vacuum	Elephant trunks, 220-221, 237, 241, 250	regulations, 281 seismic activity, 35
systems and operations;	Elevators, 23, 39, 69, 90, 114, 298	shelter in place, 39-40
other types of equipment)	Emergency action plan, 15, 22,	spills or releases, 35, 117, 125
capacitors, 76, 150, 152, 153	23, 27	staff shortages, 35, 42
codes, 149, 150, 151, 152, 154	Emergency equipment (see Safety	survival kit, 36-37
electromagnetic radiation	and emergency equipment)	training of laboratory
hazards, 162-164	Emergency preparedness	personnel, 29, 37
general principles, 149-153	administration and	vulnerability assessment,
high-current or high voltage,	supervision, 39, 42, 117, 178,	33-36
152-153	180, 281, 299	weather-related, 34-35
	, , , , , ,	· · · · · · · · · · · · · · · · · · ·

Emergency response (see also	Environmental Protection Agency	Evacuation of systems, 153, 167
Safety and emergency	(EPA), 49, 53, 56, 83, 94, 102,	Evacuations, 27, 36, 37, 39, 82,
equipment)	117, 145, 186, 187, 189, 190,	117, 120, 127, 169, 178, 299
accident procedures, 29, 117	191, 194, 195, 198, 199, 201,	Excess material (see Unused and
acid spills, 118, 120, 180	202, 205, 206, 207, 219, 253,	excess material)
burns from heat, 119	261, 267, 271, 272, 273, 275,	Exhaust systems (see also
clothing contamination, 118	276, 277, 278, 279-280, 281	Chemical hoods)
cold burns, 119	Environmental rooms (see also	benchtop ventilated
convulsions, 119	Cold rooms)	enclosures, 143, 220, 228,
cuts, 118-119	acids in, 245	240
	aerosols in, 245	
eye splashes, 118 fires, 27, 121-122		canopy hoods, 220, 237, 239, 247, 298
	alarm audibility in, 245, 299	
gas cylinder leaks, 120-121	alternatives to, 245	clean benches/laminar-flow
general procedures, 181	compressed gases in, 245	hoods, 143, 219, 221, 239,
information sources, 48	design, 245	248, 250
ingestion, 119	guidelines for working in, 245	downdraft hoods or tables,
notification of personnel, 117	Equipment (see also Electrical	220, 237, 239
skin exposures, 118	equipment; Safety and	elephant trunks, 220-221, 237,
spills, 28-29, 118, 120	emergency equipment;	241, 250
training, 29	Vacuum systems and	filters, 239, 243, 302
treatment of contaminated/	operations)	flammable-liquid storage
injured personnel, 117-119	accidents with, 149, 150, 151,	cabinets, 239-240
unconscious victims, 119	153	fume extractors, 237, 239
Engineering controls, 14, 220	for acid use, 88	gas cabinets, 239
(see also Chemical hoods;	alarms, 216	hybrid, 242
Gloveboxes)	cutting and drilling tools, 164	manifolded (common header),
Environmental health and safety	glass components, 167-168,	242
(EHS) management systems	171-172	room purge, 242
(see also Chemical Hygiene	high-termperature, 27	slot hoods, 220, 237, 238
Plan; Chemical management	incompatibility with	snorkels, 143, 220-221, 226, 237,
program; Emergency	corrosives, 50, 76, 88, 165-	238, 240, 241, 250, 251, 298
; Inspections and audits;	166, 167, 170, 171, 174	stacks, 242-243
Safety rules and policies)	inspections, 24	ventilated balance enclosures,
change management, 13	low temperature, 172-174	220, 238
elements, 10, 11	noise extremes, 164	Exits and passageways, 27, 28, 39,
employee safety training	pressure extremes, 170, 172	95, 113, 117, 122, 123, 127,
program, 29	repair and maintenance,	193, 213, 214, 264, 277, 299
example, 13-14	114-115	Experiment planning (see also
functions, 14	rotating, 27, 160, 162, 163	Hazard evaluation; Risk
implementation, 12	safety switches, 27	assessment)
information sources, 11, 14	water-cooled, 149	access control, 123-124
management commitment to	Ergonomics, 77, 149, 164, 216, 239	change management, 13
performance, 3, 10	Ethane, 62	corrosives, 61, 66
performance measurement,	Ethanol (ethyl alcohol), 67, 196,	demonstrations and magic
12-13	206, 270, CD	shows, 116
planning, 10-12	Ethers, 72, 114, 136, 138 (see also	designated areas, 123
policy and policy statement, 10	specific compounds)	emergency response to
principles, 13-14	Ethidium bromide, CD	accidents and spills, 125
regulations, 10	Ethyl acetate, 72, 190, CD	explosive and highly reactive
review by management, 13	Ethyl benzene, 190	substances, 130-140
safety committees, 12, 16-17,	Ethyl chloromethyl ether, 63	highly toxic substances, 64,
23, 24-25, 64, 276	Ethyl ether, 190	122-122
staff and responsibilities, 3	Ethylene dibromide (EDB), CD	minimizing exposure, 124-125
Environmental health and safety	Ethylene glycol ethers, 62, 72, 149	multihazardous materials, 125
policy, 10	Ethylene oxide, 60, 137, 273, CD	protocols, 123
policy, 10	Daty iche Oxide, 00, 107, 270, CD	P10100013, 120

scaled-up reactions, 13, 115-	Exposure	Filters and filtration
116, 130	airborne contaminants, 60, 107,	activated alumina, 136, 160,
storage and waste disposal, 125	178, 219, 296	236
unattended experiments, 116	biohazards, 51	activated carbon, 73, 136, 204,
working alone, 116	duration and frequency, 19, 56	231, 236
Expiration (see Shelf life and	engineering controls, 108	for aerosols, 124, 236, 301,
expiration dates)	eye protection, 108-109	302-303
Explosive and highly reactive hazards	highly toxic substances, 56, 64, 86, 109-110, 124-125, 274	air, 124, 126, 142, 143, 178, 179, 221, 236
acids, 70, 71, 96, 130, 131, 136,	limits, 51, 60, 81 (see also Lethal	aqueous-based wastes, 195
139-140, 214, 224	dose/lethal concentration)	biosafety cabinets, 236, 246,
airborne concentrations, 65,	minimization, 18-19, 51, 56, 64,	247, 248
66-67	86, 107, 108-113, 124-125,	in chemical hoods, 196, 220,
alkalis and bases, 69, 70, 73,	178, 219, 274, 296	231, 232, 235, 236
130-131, 190	radioactive materials, 81	clean rooms, 243
azo compounds, 72	safety rules and policies, 18-19	disposal of contaminated
boiling eruptions, 73	risk assessment, 57-58, 209	filters, 107, 191, 192
catalysts, 130	routes, 18-19 (see also Eye	in exhaust systems, 239, 243,
conducting reaction	contact and effects;	302
operations, 133	Ingestion hazards;	flammable paper, 139
cryogens, 131	Inhalation hazards; Injection	gas phase, 236
decomposition rates, 130	hazards; Skin contact and	for gases, 153, 223, 235, 236,
emergency planning, 130	effects)	237, 240, 247, 302
experiment planning, 130-140	signs and symptoms, 60	HEPA, 79, 124, 126, 143, 145,
gases, 133, 135, 136, 140-141,	Extension cords, 151-152, 159,	221, 231, 234, 235, 236, 239,
172, 174	217	243, 247, 248, 302-303
glassware, 70, 72, 73-74, 109, 131-	Eye contact and effects	hydrogenation reactions, 130 molecular sieves, 236
132, 136, 153, 157, 174, 175	corrosives, 58, 61, 135, 141, 190 emergency response, 118	nanomaterials, 79, 142, 143,
hydrogenation reactions, 135 incompatibles, 130-131, 140	protection against, 15, 26, 36,	145, 221, 236, 240, 244, 248
information sources	61, 75, 108-109, 114, 124, 131,	oil filters, 179
list of materials requiring	132, 144, 162, 173, 174, 176	radioactive particles, 236
special attention, 135-140	toxic chemicals, 58	replacing filters, 236
other oxidizers, 73	Eyeglasses	in respirators, 178-179
peroxides and peroxidizables,	contact lenses, 36, 109, 127, 301	solvent use, 84
19, 72-73, 133-135	prescription, 109, 164, 176	ultra-low penetration air
personal protective apparel,	safety, 26, 36, 75, 108, 109, 124,	(ULPA), 236, 248
132	132, 144, 162, 176	vacuum cleaners, 121, 145,
powders and dusts, 19, 73	Eyewashes and eyewash units,	302-303
protective shields and devices,	15, 27, 28, 29, 34, 117, 118,	Fire
131-132	125, 128, 176, 180, 181, 217,	code requirements, 11, 22, 27,
quantities of reactants, 132-133	218, 273, 297, 299	51, 89, 95, 98, 100, 113, 114,
reaction rates, 130		128, 151, 154, 214, 216, 243,
risk assessment, 70-74, 132	F	270, 272-273
scaling up experiments, 130		on clothing, 122, 178, 180, 181
shielding, 109, 110, 130, 131,	Face shields, 26, 61, 108, 109, 114,	control, 140, 178
161, 174	131, 132, 138, 144, 162, 173,	electrical, 68, 76, 150, 177, 178
Exports and imports	174, 176 Facilities (see Laboratory facilities)	emergency response, 121-122
biological materials, 280-281 chemical exports, 23, 279-280	Facilities (<i>see</i> Laboratory facilities) Fail-safe devices, 40, 150, 156	information resources, 51-52 vulnerability assessment, 34
imports from R&D Labs, 280	Falls (see Slips and falls)	Fire department inspections, 25
R&D exemption, 279	Federal Water Pollution Control	Fire Protection for Laboratories
record-keeping requirements,	Act, 271	Using Chemicals, 51
280	Ferrous sulfate, 134, 136	Fire Protection Guide to Hazardous
TSCA requirements, 279-280	Fiberglass, 57, 157-158, 233	Materials, 52, 68
*	•	

Fire safety equipment	Floods, 34	inert, 116, 128, 129, 135, 140,
alarms, 15, 27, 28, 43, 107, 117,	Fluorides, 137, CD	145, 159, 160, 165, 168, 169,
121, 122, 127, 166, 176-177,	Fluorination, 86	173, 174
178, 217, 245, 249, 299	Fluorine, 61, 86, 137, 141, 170, CD	inhalation, 55, 57, 141
automatic fire-extinguishing	Formaldehyde, 54, 57, 61, 139,	in-house systems, 100
system, 21, 178, 244	207, 220, 273, CD	liquefied, 69-70, 114, 135, 138,
blankets, 15, 28	Formalin, 206, 273	140-141, 164, 166, 172-174,
fire extinguishers, 15, 16, 27-28,	Food and beverages, 109, 300	176, 242
29, 34, 37, 43, 68, 113, 117,	Footware, 120, 144, 175-176, 244,	oxidizing, 50, 70, 141, 291
121-122, 125, 127, 128, 130,	300, 302	packagings, 102, 198
138, 140, 156, 177-178, 180,	Freezing, 72, 119, 149, 169,	pressure reactions, 171
181, 193, 217, 234, 299	176, 192, 224, 234 (see	reactive, 57, 70, 133, 135, 140,
fire hoses, 178	also Refrigerators and	141
heat sensors and smoke	refrigeration)	respirator protection, 179
detectors, 34, 100, 178, 249	Friction, 70, 132, 133, 161, 190, 290	toxic, 57, 85, 122, 140, 172, 190,
training, 34	Friction tape, 172, 174-175	261, 275
First aid	Frostbite, 141, 172, 173	tracer, 221
equipment and supplies, 15,	F-TEDA-BF4, 86	waste, 198
28, 36, 125, 137, 180	Fume extractors, 237, 239	Gastrointestinal tract, 58 (see also
information, 27, 48, 49, 50, 51,	Furnaces, 75, 146, 154, 157, 158, 172	Ingestion hazards)
52, 66, 94, 299 procedures, 137-138, 152, 181	1/2	Gauges diaphragm, 167
regulations, 272, 299		liquid-level, 167
training, 16, 29, 37, 137, 138, 299	G	magnehelic, 249
Flammability and flammable	Gamma rays, 81, 203	McLeod, 75
chemicals (see also Fire;	Gas burners, 128	pressure, 88, 167, 172, 180, 243,
Flash; Ignition sources	Gas cabinets, 239	249
and causes)	Gas chromatographs, 24, 216, 220,	thermal conductivity, 75
acids, 67, 68, 69, 98, 99, 128-129	237, 241	vacuum, 75
aerosols, 50, 99, 290	Gas cylinders (see Compressed	Genetic Toxicology Data Bank, 53
alcohols, 99	gas cylinders)	Gifts (see Donations and gifts of
basic precautions, 129	Gases (see also Compressed gases;	chemicals)
catalyst ignition of, 130	specific gases)	Gland joints, 166, 169
characteristics, 65-67	byproducts of reactions and	Glass and glassware (see also Cuts)
classification systems, 67-69	fires, 73, 122, 130, 131, 153,	airbaths and tube furnaces, 158
containers, 22, 23, 58, 69, 88,	190	amber, 73
98-99, 128, 129	corrosive, 61, 121, 140-141, 165-	beads, 140
filter paper, 139	166, 167, 170, 172, 174	breakage, 35, 74-75, 76, 114,
gases, 69-70, 74, 114, 121, 129,	cryogenic, 75, 90, 100, 173, 242	115, 119, 191, 258
165, 170, 190	detectors and alarms, 34, 137,	cleaning and decontamination,
information sources, 65	168, 169, 249	70, 73, 85, 86, 93, 114, 124,
LCSSs, CD	drying, 136	138, 214, 215, 302
limits, 66-67	equipment composition and,	contaminated, 58, 114, 138, 144
liquids, 129	174	cooling, 138
procedures for working with, 127-130	explosive, 133, 135, 136, 140-	cutting, 16-17
risk assessment guide, 66	141, 172, 174 exposure monitoring, 228	drying, 17, 85, 156, 157, 159 equipment, 167-168, 171-172
storage hazards, 98-99	filters, scrubbers, and exhaust	explosion hazards, 70, 72, 73-
substances, 65	systems, 153, 223, 235, 236,	74, 109, 131-132, 136, 153,
Flash arrestors, 129, 170	237, 240, 247, 302	157, 174, 175
Flash hazards, 128, 152	flammable, 50, 69-70, 74, 114,	for food and beverages, 109,
Flash lamps for lasers, 151	121, 129, 135, 141, 165, 170,	300
Flash points, 65, 67, 68, 69, 86, 99,	172, 190	handling and storage of, 16-17,
127, 128, 140, 158, 188, 190,	hydrogenation reactions, 135,	76-77, 115, 164, 176, 223, 229,
290	171	300

heating elements, 155	heat-resistant, 158	Haloacetylene derivatives, 71
high-temperature operations,	inspection, 15	Halocarbons, 70
109	insulated, 152, 173, 176	Halogens and halogenating
hose connections, 115	Kevlar [®] , 111, 115, 176	agents, 62, 71, 73, 115, 130,
inspection, 26, 66, 76-77, 115,	latex, 111, 112, 176	136, 137, 141, 187, 189, 190,
174	leather, 111, 115, 132, 176	192, 193, 205
pressure and vacuum	neoprene or rubber, 111, 112,	Halon, 128, 178
equipment, 26, 74-75, 109,	138, 139, 152, 233, 303	Hands (see Gloves and hand
115, 131-132, 135, 149, 153,	nitrile, 111, 112, 144, 176	protection)
167, 170, 171-172, 174-175	polyethylene, 112	Hazard classifications, 26-27
protective apparel and	polyurethane, 112	Hazard evaluation (see also Risk
equipment, 26, 36, 75, 108,	poly(vinyl chloride), 112	assessment)
109, 124, 132, 172, 176, 214	radiation-resistant, 80	administration and
reactivity with, 137, 141	selection and use guidelines,	supervision, 47, 55, 60, 66,
recycling, 94	61, 109, 111-113, 118, 120, 124, 126, 127, 131, 144, 149,	75, 108, 123, 131, 301
shielding materials, 177, 225, 229, 248	162, 172, 173, 176, 247, 301	basic principles, 53-58 environmental, 49
stirring and mixing devices	Silvershield [®] or 4H [®] , 112, 138	explosivity, 70-74
and, 154	spill cleanup, 48, 120, 121	flammability, 65-70
stoppers, 133, 154	storage and replacement, 112,	health hazards, 26, 48, 50
storage in, 73, 94, 99, 100, 129,	144, 176	information sources, 47-53
133, 137, 154, 191, 192, 302	Viton [®] , 111, 112	nanomaterials, 49, 77-79
tubing, 76, 115, 164	Goggles (see also Personal	physical hazards, 48, 50, 74-77
windows, 132, 258	protective equipment), 19,	reactivity, 70
waste disposal, 77, 114, 115,	26, 108-109, 120, 132, 138,	toxicity, 53-65
203, 205	144, 162, 173, 176, 233	Hazard reduction (see Waste
Glassblowing, 109, 115, 167	Governmental laboratories, 4-5,	management)
Glasses (see Eyeglasses; Goggles;	20	Hazardous Materials
Personal protective	Green chemistry	Transportation Uniform
equipment)	degradable products, 86	Safety Act, 277
Globally Harmonized System	experiment planning and risk	Hazardous Substance Data Base,
(GHS) for Hazard	assessment, 87	53
Communication, 47 n.1,	less toxic reagents, 85	Health hazards (see also Acute
49-50	mercury replacements, 87-88	toxicity; Carcinogens;
Glovebags, 234	microscale work, 84-85	Chronic toxicity and health
Gloveboxes, 19, 58, 110, 112, 123,	multihazardous waste	effects; Exposure)
124, 126, 127, 145, 220, 221,	minimization, 87	information sources, 48
243, 244, 247, 248, 293, 298,	real-time controls, 86-87	Heat of reaction, 131
300, 302	safer solvents and other	Heat sensors and smoke
Gloves and hand protection (see	materials, 85-86	detectors, 100, 178, 249
also Personal protective	waste prevention, 84	Heat transfer, 115, 130, 158
equipment), 19, 23, 26	wet chemistry elimination, 85	Heaters and heating equipment
absorbency, 176	Ground-fault circuit interrupters,	(see also Hot air; Hot plates;
butyl, 111	150, 152, 159, 217-218	Ovens)
chemical-resistant, 111, 124	Grounding, 22, 66, 69, 76, 128,	general precautions, 154-156
cleaning/decontamination, 111, 124, 176, 206	129, 132, 150, 152, 153, 155, 158, 159, 168, 193	mantles and tapes, 157-158 oil, salt, or sand baths, 158
corrosion-resistant, 36, 111, 113	130, 137, 100, 173	tube furnaces, 158
cut-resistant, 16-17, 77, 111, 115,		Heavy metals, 56, 70, 86, 132, 135,
176	Н	136
disposable, 112	Hair	Helium, 62, 76, 135, 143, 163, 169,
disposable, 112 disposal, 144, 203, 205, 208	dryers, 159	171, 172
double gloves, 111, 132, 144,	facial, 178-179, 181	HEPA filters, 79, 124, 126, 143,
176	long, 163, 300	145, 221, 231, 234, 235, 236,
gauntlet-type, 144	Halides, 14, 61, 70, 136, 210	239, 243, 247, 248, 302-303
J1 ·	, , , , , , , , , , , , , , , , , , ,	· · · ·

Hexafluoropropylene, 96 Hydrogen chloride, 54, 57, 136, Hexamethylphosphoramide, 170, 303 Hydrogen cyanide, 56, 60, 62, 70, CD Hexane, 62, 67, 86, 120, CD 125, 166, 275, 301, 303, CD Hydrogen fluoride (HF), 61, 96, High-performance liquid chromatography, 69, 134, 137, 141, CD 204, 216, 241 Hydrogen peroxide, 61, 69, 70, 96, 130, 138, 139, 260, 291, CD High-pressure reactions, 26, 74, 165 (see also Pressure vessels Hydrogen phosphides, 141 and reactions) Hydrogen selenide, 141 Hydrogen sulfide, 56, 60, 69, 96, High school laboratories, 3, 218, 129, 141, 170, 189, 275, 303, 277 Horseplay, 300 96-97 Hoses, 115, 149, 156, 169, 170, 171, Hydrogenation reactions, 74, 130, 135, 171, 224 178, 179, 217, 237 (see also Tubing) Hot air baths, 129, 133, 154, 156, 158 guns, 69, 154, 159 Ice, 74, 77, 113, 119, 154, 164, 216, Hot plates, 66, 128, 136, 149, 154, 224 (see also Dry ice) Ice baths, 172 155, 156, 157, 158, 225 Housekeeping and cleaning (see Ice chests, 109 also Laundry) Ignition sources and causes acids, 73, 86, 138, 139-140 catalysts, 130 and aerosols, 114 compressed or liquefied gases, chemical hoods, 223 69-70, 121, 170 dry sweeping, 114, 145, 302 controlling/eliminating, 42, 65, general practices, 19-20 98, 99, 113, 128, 129, 135-136, glassware, 70, 73, 85, 86, 93, 153, 154, 228, 240 114, 124, 138, 214, 215, 302 electrical equipment, 21, 69, 76, inspection of, 23, 24, 114, 297, 128, 129, 149, 153, 154, 245 298 gas burners and heating equipment, 69, 128, 129 nanomaterials and, 144-145 personal, 300 heating elements and hot rules, 113-114, 298 surfaces, 66, 128, 136, 156, safety aspects, 19-20, 77, 113-159, 160 114, 122, 163 nanomaterials, 142 security aspects, 20 oxidants other than oxygen, 69 vacuum cleaners, 121, 145, pyrophorics, 70, 135-136 302-303 risk assessment, 34, 65, 66 Hydrazine, CD shock-sensitive compounds, Hydrides, 70, 90, 86, 122, 128, 136, 72, 136 138, 177, 178, 210 spontaneous combustion, 69, 73, 130, 135, 136, 139, 140, Hydrobromic acid, CD Hydrocarbons, 52, 63, 115, 133, 136, 140, 168, 177, 190, 236 static discharge from fabric, Hydrochloric acid, 61, 96, 134, 113, 128 188, 189, 205, 209, CD Ignition temperature, 65-66, 67, 68, 155 Hydrocyanic acid (see Hydrogen cyanide) Incineration and incinerators Hydrogen, 34, 67, 69, 70, 72, 73, waste, 85, 87, 185, 193, 195, 196, 81, 129, 130, 135, 136, 137, 197, 199, 203, 205, 206, 207, 139, 140, 141, 165-166, 172, 208, 235, 237, 278, 297, 300, 173, 174, 190, CD 302, 303

Incompatibility of chemicals acids, 70, 73, 96, 98, 100, 128-129, 138, 139 alcohols, 73, 130, 139 alkalis and bases, 73, 128 compressed gases, 96 with equipment materials and fittings, 166, 167, 169 explosive and highly reactive, 130-131, 140 information sources, 52 storage guidelines, 21, 22, 27, Induction heaters, 75 Induction motors, 151, 154 Induction periods, 73, 74, 116, 130 Industrial hygienists, 3, 29, 47, 52, 60, 62, 108, 164, 228, 229, 231, 237, 249 Industrial laboratories, 2, 3, 4-5, 18-19, 48, 52, 65, 186, 194, 196, 242, 263 Inert gases, 116, 128, 129, 135, 140, 145, 159, 160, 165, 168, 169, 173, 174 Infectious agents (see Biological materials and biohazards) Information sources (see also Documentation and recordkeeping; Education and training in safety practices; Labels and labeling; Laboratory Chemical Safety Summaries; Material Safety Data Sheets) ADA compliance, 6-7 biohazards, 51, 79, 80, 126, 189, 246, 260, 276 carcinogens, 48, 50, 52, 53, 63, 291, 304 compressed gases, 15 computer services, 52-53 corrosives, 52, 303 cryogens, 52 fire protection, 51-52 first aid, 27, 48, 49, 50, 51, 52, 66, 94, 299 flammability, 51-52 GHS, 47 n.1, 49-50 incompatible chemicals, 52 informal forums, 53 LCSS preparation, 52, CD reactivity of chemicals, 52 risk assessment, 47-53 toxicity, 48, 50, 51, 52, 59

Infrared radiation, 75, 162, 176	Integrated Safety Management	Ion exchange resins, 204
Ingestion hazards, 58, 109-110, 119	system, 13-14	Ionizing radiation, 62, 80, 81, 162,
Inhalation hazards, 55, 57-58, 61,	Interlocks, 40, 108, 124, 149, 155,	271
110, 141, 221	170	Irritants, 50, 55, 58, 59, 60, 61, 112,
Inhibitors, 70, 72, 73, 134	International Agency for Research	137, 138, 139, 140, 141, 169,
Injection hazards, 58, 111	on Cancer (IARC), 63, 275,	179, 290
Injuries and illnesses (see also	29 1	Isopropyl alcohol, 67, 172, 173
Accidents)	International Air Transport	Isopropyl ether, 72
acid burns, 58, 61, 118, 137, 138,	Association, 23, 101, 271, 279	
180, 214, 260	International Association	К
alkalis and bases, 58	for Assessment and	K
assisting recovery and return	Accreditation of Laboratory	Kekulé, August, 1
to work, 12	Animal Care, 23	
cuts, 58, 76, 115, 118-119, 149,	International Chemical Safety Cards,	L
164	51	-
emergency response, 117-119	International Civil Aviation	Labels and labeling
regulations, 281	Organization, 279	acids, 69
Inorganic compounds, 28, 52, 57,	International Code Agency, 98	bar code, 19, 91
61, 62, 73, 96, 97, 120, 125,	International Code Council, 273	color coding, 100, 165
130, 134, 135, 136, 139, 189,	n.1	compressed gas cylinders, 140,
196, 210, 273, 279	International Commission on	165
Inorganic Syntheses, 209	Non-ionizing Radiation, 76	corrosives, 69, 165, 192, 199
Inspections and audits	International Conference of	experimental materials, 94
alarm systems, 43, 193, 245,	Building Officials, 273 n.1	flammability and flash point,
249, 250	International Electromagnetic	65, 68
checklists, 23, 25, 26, 27	Field Project, 76	GHS system, 47 n.1, 49-50
compressed gas cylinders, 26,	International Labour	hazard communication, 49-50,
27, 164, 165, 169, 170	Organization, 49	51, 68, 94
conducting, 26	International Mechanical Codes,	information to be included on,
containers, 22, 135	242	94
corrective actions, 26	International Organization for	inspection of, 22, 23, 27
EHS management system	Standardization (ISO), 78	and inventory and tracking,
performance, 24-25	n.3, 243, 280	94
elements of, 25-26	International Programme on	nanomaterials, 103, 145
fire department, 25	Chemical Safety, 51	quality of information on, 51
glassware, 26, 66, 76-77, 115, 174	International Toxicity Estimates	reading and heeding, 22, 28
hazardous waste, 26	for Risk (ITER), 53	regulatory standards, 51, 92,
items to include in, 26-27	Inventory and tracking (see	268, 270, 271, 272, 274, 277,
peer, 24	also Labels and labeling;	279, 294, 298
PPE, 15, 180	Recycling)	replacement, 92
preparing for, 25	benefits, 22	by suppliers, 21, 51, 90, 94
pressure equipment, 165, 167,	compressed gases, 140, 164	transfer and storage containers,
170-171	computerized, 23, 91	21, 51, 87, 94, 154, 277
program audits, 24	by container, 91	verification on receipt, 90, 298
regulatory agencies, 25	and emergency response, 94	warning, 51, 101
reports, 26	exchanges between	waste, 23, 187, 191, 192, 193,
routine, 24	laboratories and stockrooms,	194, 197, 198, 203, 206
self-audits, 24	92-93	Laboratory animals
storage, 27	general considerations, 90-92	biohazards, 80, 205
types, 24-25	information in, 22-23	carcinogenicity testing and
		· .
ventilation systems, 250	regulations, 22 safety issues when performing,	results, 63, 275, 291-292, 302 disposal of tissues and
Insurance, 36, 42, 43, 95, 102, 116,	23	-
198, 267, 269 Integrated Rick Information	security issues, 23	carcasses, 205, 206, 207-208, 303
Integrated Risk Information	Iodine, 61, 81, 87, 136, 159, 203, CD	facilities, 215, 239, 262
System, 53	100HE, 01, 01, 07, 100, 107, 200, CD	1aciii11e3, 210, 207, 202

lighting, 258

normal (Level 1), 263

personal protection for working with, 303 security/protection of, 37, 260-261, 262 toxicity testing and results, 54-55, 56, 59, 60, 62, 78, 269, 295, 302-303 Laboratory Chemical Safety Summaries, 91, 108, 129, 140 access to, 91, 123 content, 60, 62, 63, 68 criteria for selection of, 50-51 limitations of, 50 preparation of, 51, 52, 55, 63, CD and risk assessment, 55, 59, 60, Laboratory coats, 15, 19, 26, 109, 113, 126, 131, 132, 138, 144, 172, 214, 244, 247, 301, 303 Laboratory Decommissioning Standard (ANSI), 253, 254, 269 Laboratory facilities (see Closure or loss of institution or building; Decommissioning; Design of laboratory facilities: Ventilation and environmental control systems) computer laboratories, 213, 214, 216 Laboratory security (see also Security plans) administration and supervision, 123, 145, 262 alarms, 124, 256, 258, 264 barriers, 258 basics, 256-259 biohazards, 256, 260, 262, 263, 264 checklists, 262 chemicals of interest, 23, 89, 259, 260, 261, 262, 270, 275 controlled substances, 261 controversial research and researchers and, 35 and culture of safety, 7 door locks, 257 dual-use materials, 259-260, 262 elevated (Level 2), 263-264 high (Level 3), 264 information and data, 23, 258-259, 262

operational, 258 physical and electronic, 256-258 protesters and civil disobedience, 35 radioactive materials and related equipment, 261 requirements, 260-261 research animals, 260-261 risks to, 7 systems integration, 259 terrorist attacks, 35-36 video surveillance system, 258 vulnerability assessment, 261-262 Laboratory supervisor, 17, 22, 24, 26, 75, 117, 177, 178, 180, 231, 297-298, 299 Laboratory Ventilation Standard (AIHA/ANSI), 249 Labpacks, 87, 186-187, 193, 194, 198, 199 Lamps, 75, 151, 162 Landfills, 185, 190, 193, 194, 195, 196, 197, 300 Lasers, 19, 29, 34, 75, 76, 109, 137, 149, 151, 162, 176, 214, 215, 216, 217 Laundry, clothing, 109, 113, 118, 144, 175 Lead and lead compounds, 62, 73, 81, 136, 166, 189, 193, 202, 203, 205, 206, 234, 273, 301, CD Leadership, 2, 4, 37 Leaks chemical hoods, 221, 224, 225, 226, 227, 229, 231 compressed gas cylinders, 120-121, 140, 166, 169, 170 corrosive gases, 121 detection, 100, 165, 171 flammable gases, 35, 69, 100, 120-121, 166, 170 gas cabinets, 239 gloveboxes, 243, 302 microwave, 159 packages, 21, 90 refrigerant, 245 reporting, 245 secondary containment and, 23, 98, 113, 114, 125, 127, 145, 298, 301

toxic gases, 121 waste containers, 185, 192, 197 water, 151 Lecture bottles, 89, 100, 165, 239 Lethal dose/lethal concentration, 54-55, 56, 59, 60, 275 Liability and litigation, 6, 102, 116 Life cycle analysis, 86, 251 Lifting injuries, 164 Light and lighting, 21, 41, 72, 100, 116, 154, 172, 216, 224, 245, 250, 252, 258, 262, 301 explosion hazards, 70, 130, 133, 248 fire hazards, 67, 136 Liquefied gases, 69-70, 114, 135, 138, 140-141, 164, 166, 172-174, 176, 242 (see also Compressed gases; Cryogens; specific gases) Liquid scintillation counter, 85, 203 Liquid scintillation fluid, 202 Lithium, 70, 130, 178 Lithium aluminum hydride, 90, 96, 138, CD Lithium hydroxide, 96 Lower explosive limit (LEL), 66-67, 68, 228, 240 Low-valent metal salts, 70

M

Magnesium, 73, 122, 130, 131, 136, 141, 159, 178 Magnesium hydroxide, 209 Magnetic fields, 76, 163 Maintenance and repair, 4, 17, 24, 41, 76, 102, 110, 114-115, 143, 149, 150, 162, 166, 167, 171, 180, 218, 221-222, 231, 232, 241, 248-249, 250, 252, 257, 295, 297, 298-299 Manometers, 75, 87, 88, 249 Material Safety Data Sheets (MSDSs) access to, 27, 47-48, 89, 91, 268 audience for, 48-49, 78-79 content, 22, 48, 50, 62 for emergency responders, 117, 118, 119, 138, 181 for experimental materials, 101, 280, 281 guidelines on use of, 13, 15, 21, 22, 51, 59, 97, 108, 110, 118, 123, 127-128, 140

:- (Mathadian tallatana 72 100	in sin 102 205 207
information sources for	Methyl-isobutyl ketone, 72, 190	incineration, 203, 205, 206, 207,
preparing, 52-53	Methyl lithium, 96	208
limitations, 49, 91	Methyl methacrylate, 72, 177	labware, 206, 208
for nanomaterials, 103, 104	1-Methyl-2-pyrrolidinone, 72	medical waste and sharps,
regulatory requirement, 47,	Methylene chloride, 57, 64, 160,	206-207
270, 272, 274, 279, 280	190, 273	minimization, 202, 203, 207
and risk assessment, 47-49, 51,	Methylene diphenyl diisocyanate,	offsite management, 207
55, 59, 61, 62	61	radioactive-biological
spills and, 28, 29	Methylenedianiline, 273	laboratory waste, 207-208
from suppliers, 72, 89	Methylmercury, 275	risk assessment, 202
McLeod gauges, 75	Met-L-X, 122, 130, 178	sewer disposal, 206
Mechanical shock, 70, 130, 131,	Microscale and miniaturized	storage, 203-204
174-175	operations, 5, 49, 70, 74, 84-	Multimeters, 152
Melting points, 48, 116, 158	85, 131, 203	
Mercaptans, 210, 240	Microwave ovens, 141	N
Mercury, CD	acid digestion bombs, 159	
bubblers, 170	containers in, 75-76, 159	Nanomaterials
decontamination, 254	Microwaves, 75-76, 162	airborne concentrations, 135,
incompatibilities, 166	Molecular sieves, 204, 236	143, 144, 248
in meters and gauges, 75, 87-	Molecular weights, 48	in biosafety cabinets, 248
88, 157	Monitoring (see also Laboratory	in chemical hoods, 248
MSDSs, 303	security)	clothing and PPE, 143, 144
properties, 57	aerosols, 144	containers, 103, 143, 145
reclamation, 93	airborne concentrations, 60,	controls for R&D laboratories,
replacement, 87-88	143, 144, 208, 228, 298	141-146
spills, 121, 157, 254	chemical hoods, 17, 23, 124,	determining appropriate
toxicity, 62, 75	223, 225, 226, 231, 236,	controls, 142-143
waste, 174, 195, 196, 205, 206	297-298	engineering controls, 143-146,
Metal acetylides, 71	cold storage, 97-98	248
Metal alkyls, 128, 178	exposure, 16, 81, 228, 269, 289,	facilities, 248
Metal azides, 210	292, 293-294, 295	filters 79, 142, 143, 145, 221,
Metal fires and explosions, 132,	heating equipment, 157, 158	236, 240, 244, 248
140, 141, 160, 177-178, 254	nanomaterials, 79, 144, 248	hazards, 77-79
Metal fulminates, 71	pressure equipment, 135, 141,	housekeeping, 144-145
Metal halides, 70, 210	165, 166, 243	information sources, 142
Metal hydrides, 70, 122, 128, 136,	radiation, 81, 82, 127, 132	marking, labeling, and signage,
178, 210	regulatory compliance, 20, 123,	145
Metal hydroxides, 61	272, 273, 294	monitoring and
Metal nitrides, 70	spills and leaks, 35, 79, 140,	characterization, 111
Metal oxides, 57, 70, 86, 141	168, 245, 249	offsite transport and shipment,
Metal perchlorates, 254	ventilation systems, 252, 298	103
Metal peroxides, 71, 73, 130-131	wastes, 197-198	onsite transfer and transport,
Methane, 62, 70, 129, 172	Multihazardous waste	103-104
Methanol, 57, 65, 67, 69, 96, 190,	animal tissues and carcasses,	personnel competency,
196, 202, 203, 204, 214, 303,	206, 207-208	145-146
CD	chemical-biological waste,	planning and hazard
Methyl acetate, 204	205-207	assessment, 142
Methyl ablarida 141	chemical-radioactive-	regulations, 280
Methyl chloride, 141	biological waste, 208	ventilation systems, 143, 248
Methyl cyclopentane, 72	chemical–radioactive waste, 202-205	waste disposal, 145
Methyl cthyl ketone (MEK) 67		work area design, 143
Methyl ethyl ketone (MEK), 67,	commercial disposal services,	work practices, 145
CD Methyl fluoregulfenate 60	205	NARM (naturally-occurring
Methyl iodida (see CD)	hazard reduction (treatment),	or accelerator-produced
Methyl iodide (see CD)	204-205	radioactive material), 80, 202

National Electrical Code (NEC),	Nitrogen, 34, 62, 69, 73, 74, 75, 76,	Oily rags, 178
149, 152	77, 111, 129, 130, 131, 133,	Olfactory fatigue, 60
National Emission Standards for	134, 135, 138, 140, 153, 154,	Online services (see Computer
Hazardous Air Pollutants,	158, 159, 160, 163, 164, 165,	systems and services; specific
270	169, 170, 171, 172, 173, 174,	databases)
National Fire Protection	239, 243, 245	Open houses, 25
Association	Nitrogen compounds, 71	Ordering chemicals (see
chemical hood standards, 224,	Nitrogen dioxide, 56, 57, 60, 61,	Acquisition of chemicals)
231	275, 303, CD	Organic compounds, 52, 58, 61, 62
electrical code, 149, 152	Nitrogen mustard, 260	acetylenic, 135
fire code, 22, 51, 67, 68, 95, 98,	Nitrogen oxides, 138	adsorbents, 236
224, 231, 243, 270, 273	Nitrogen triiodide, 70, 136	air emissions, 278
fire protection guidelines, 52,	Nitrosamines (see CD)	azides, 70, 71, 72, 136
68	N-Nitroso compounds, 70, 71,	compatible, 98
hazard classification, 68, 69	138-139, 273, 302, 303	drying, 157
storage regulations, 22, 95, 98,	Noise extremes, 77, 132, 149, 164,	explosion hazards, 138, 139-
273	214, 216-217, 229, 250, 272	140, 141, 173
National Institute for	Notifying personnel of	flammability/combustion, 65,
Occupational Safety and	emergencies, 117	69, 159, 190, 205
Health (NIOSH), 48, 51, 52,	Nuclear Regulatory Commission	halides, 136, 205
53, 59, 60, 64, 66, 77, 78-79,	(USNRC), 79, 81, 82, 127,	mercury, 62
		nitrates, 70, 130
109, 111, 112, 141, 142, 144,	189, 201, 202, 204, 205, 207,	
164, 178, 179, 268, 269	208, 253, 261, 271, 276	oxidizable, 73, 208
National Institutes of Health, 77,	Nucleating agents, 73, 129	peroxides, 50, 70, 72, 73, 100-
79, 126, 201, 203, 207, 260		101, 130-131, 133-135, 189,
National Library of Medicine, 52,	0	210, 290, 291
53, 63	Occupational and Educational	solvents, 62, 70, 76, 93, 111, 112,
National Pollutant Discharge	Occupational and Educational	136, 138, 139, 140, 151, 153,
Elimination Systems	Eye and Face Protection, 108	157, 159, 177, 188, 190, 196
(NPDES), 271	Occupational Safety and Health	waste, 186-187, 188, 189, 190,
National Toxicology Program	Act, 268, 270, 281	196, 203, 204-205, 208, 210
(NTP), 63, 275, 291	Occupational Safety and Health	water solublity, 188, 192, 196
Near-infrared radiation, 75	Administration (see also	Organisation for Economic Co-
Needle valves, 168	OSHA Standards)	operation and Development,
Needles and syringes, 30, 58, 111,	GHS implementation, 49	49
114, 131, 164, 206-207, 208,	information resources, 53	Organolithium compounds, 136
278	state laws, 268	Organomercurial compounds, 301
Neurotoxicity, 54, 55, 56, 59, 62,	Odor and odor thresholds, 60,	Organometallic compounds, 70,
290	92, 95, 99, 137, 139, 141, 179,	122, 130, 139, 170
Neutralization and neutralizers	187, 216, 237, 240, 293, 301	Organophosphates, 62
acids, 120, 121, 136, 137, 138,	Odorants, 70	OSHA standards
195, 196, 208, 209	Oil	chemical-specific, 273
alkalis and bases, 120, 209,	baths, 88, 93, 128, 129, 133, 154,	Control of Hazardous Energy
210	155, 156, 158	Standard, 150
Nickel, 61	bubblers, 170	enforcement, 268
Nickel alloys, 166, 174	filters, 179	exposure limits, 269, 273
Nickel carbonyl, 60, 166, 302, 303,	fires, 174	Hazard Communication
CD	PCBs, 275-276	Standard, 47, 48, 49, 51, 101,
Nitrates, 69, 70, 71, 96, 130, 138,	reactivity, 139, 140, 165, 167,	268-269, 270, 275
139, 190	169, 170	Laboratory Standard, 2, 6, 13
Nitric acid, 69, 73, 96, 120, 131,	vacuum pump, 93, 133, 153,	n.2, 14-15, 17, 18, 20, 21,
138, 139, 214, CD	173, 174	22, 48, 59, 62, 63, 101, 175,
Nitrites, 69, 71, 140	waste, 174, 277	268-269, 270, 272, 273-275,
	Oil Dri, 120	289-305

INDEX INDEX

Occupational Exposure to Bloodborne Pathogens Standard, 79, 206 Personal Protective Equipment Standard, 111, 112, 175 Respiratory Protection Standard, 110, 178, 179, 180, 270 Osmium tetroxide, 60, 260, CD Ovens drying samples, 156-157 general precautions, 156-157 microwave, 141, 159 Oxidants and oxidation (see also specific compounds)	Paracelsus, 18 Particularly hazardous substances (PHSs), 5, 13, 14, 18, 23, 55, 59, 60, 62, 63, 64, 80, 118, 216, 220, 274-275, 278, 293, 296 Particulates, 49, 57, 79-80, 144, 176, 179, 181, 221, 231, 235, 236, 237, 239, 243-244, 254 (see also Nanomaterials; Powders and dusts) Pentanes, 67, 72, 120 Peracetic acid, 303, CD Perchlorates, 69, 70, 71, 74, 98, 99, 130, 131, 139, 254	familiarity with, 22 foot protection, 175-176 glass hazards, 26, 36, 75, 108, 109, 124, 132, 172, 176, 214 PHSs and, 13 Petroleum ether, 120 Pets, 16 Phenol, 58, 61, 139, 202, 204, 303, CD Phorbol esters, 64 Phosgene, 57, 60, 85-86, 239, 260, 303, CD Phosphate buffer, 54 Phosphine, 139, 141 Phosphorus, 61, 69, 81, 90, 96, 13
acids, 69, 73, 96, 98, 120, 128-	Perchloric acid, 69, 71, 73, 96, 100,	203, CD
129, 131, 138, 188	129, 131, 139, 224, 226, 233-	Phosphorus pentachloride, 70
adsorbents, 236	234, 240, 242, 254, CD	Phosphorus pentoxide, 61, 136
corrosive, 61, 121, 138	Permanganates, 69, 73, 98, 99, 130,	Phosphorus trichloride, 139
fire hazard, 34, 69, 70, 128-129,	139, 210, 236	Physical hazards (see also specific
141	Permissible exposure limits	hazards)
gases, 50, 69, 70, 120-121, 135,	(PELs), 60, 268, 269, 273, 274,	compressed gases, 74, 291
137, 141, 169, 170, 291	292, 294, 295, 297	cryogens (nonflammable), 74
incompatibilities, 70, 73, 139,	Peroxides and peroxidizables (see	electrocution, 76
140 liquids, 69	also specific compounds) acids, 72, 134, 139	ergonomic, 77 high-pressure reactions, 74
metal oxidants, 57, 70, 86, 141	containers, 21, 69, 133, 134	information sources, 48
nonoxygen examples, 69	detection tests, 134	magnetic fields, 76
reactivity, 70, 130, 131, 139, 140	dilution, 133, 134	radio frequency and
solids, 69	distillation, 72, 134, 136	microwaves, 75-76
spills and leaks, 120-121	explosives, 19, 72-73, 133-135	sharp edges, 76-77
storage, 96, 97, 98, 99, 100, 140,	metal peroxides, 71, 73, 130-131	slips, trips, and falls, 77
170	organic peroxides, 50, 70, 72,	ultraviolet, visible, and
waste, 187, 188, 195, 204, 205,	73, 100-101, 130-131, 133-	infrared radiation, 75
208	135, 189, 210, 290, 291	vacuum work, 74-75
Oxygen, 62, 65, 66, 67, 135, CD	peroxidizable compounds, 134	Pipets and pipetting, 77, 110, 126
cylinders/tanks, 139, 163, 169 depletion, 163, 173, 179, 245	precautions for handling, 133-134	127, 206, 252 Planning (see Chemical Hygiene
gas/atmospheric, 70, 72, 73, 78,	reducing agents for, 134	Plans; Emergency action
129, 134, 135	storage, 21, 72, 100, 133-134	plan; Emergency response;
isotopes, 203	waste disposal, 134-135, 187,	Experiment planning)
leak testing, 169	188-189, 190, 210	Plastic equipment and container
liquefied, 69, 74, 135, 172, 173	Personal protective equipment	76, 88, 94, 96, 97, 98, 99, 112
monitors, 163, 173, 245	(see also Clothing and	113, 114, 115, 120, 128, 129,
oil/lubricant reactivity, 139,	protective apparel; Gloves	130, 144, 145, 149, 150, 156,
140, 165, 167, 169, 170	and hand protection;	168, 169, 172, 173, 174, 175,
scavenging/scavengers, 160	Goggles; Respirators)	191, 203, 224, 233, 234, 236,
Ozone, 57, 60, 69, 76, 139, 151,	airborne contaminants, 127,	240, 243, 244, 245, 302, 303
271, 278, CD	144, 178-180	Platinum, 61, 130, 135, 139
	corrosives, 171-172, 176 eye protection, 26, 36, 75, 108,	Polychlorinated biphenyls (PCBs), 187, 206, 270,
P	109, 124, 132, 144, 162, 176	275-276
Palladium on carbon, 139, 130,	face protection, 26, 61, 108, 109,	Polymerization, 70, 72, 73, 116,
CD	114, 131, 132, 138, 144, 162,	130, 292
Pandemic planning, 35	173, 174, 176	Polyols, 139

Potassium, 69, 70, 75, 130, 134, 140, CD Potassium amide, 72 Potassium chloride, 195, 196 Potassium cyanide, CD Potassium hydride, 122, CD Potassium hydroxide, 120, 140, 207, CD Potassium iodide, 134, 188, 189 Potassium metals, 72, 122, 134, 178, 180 Potassium permanganate, 73, 236 Potassium peroxides, 139 Powders and dusts, 55, 57, 60, 73, 78, 112, 124, 130, 131, 136, 145, 161, 177, 178, 179, 190, 222, 231, 237, 244, 248, 254, Preparation (see Emergency preparedness; Experiment planning; Procedures for working with materials) Pressure control systems/devices air, 214, 219, 240 clean rooms, 219, 243 compressed gas cylinders, 26, 164, 168, 169-170 gauges, 88, 167, 172, 180, 243, 249 precautions, 166-167 Pressure vessels and reactions (see also Autoclaves and autoclaving; Compressed gases; Vacuum systems and operations) and airborne contamination, 135 assembly and operation, 165-168 cleaning, 165 closed-system vessels, 166 compatibility of equipment materials and fittings with chemicals, 166, 167, 169 gas monitors and alarms, 168 glass equipment, 26, 74-75, 109, 115, 131-132, 135, 149, 153, 167, 170, 171-172, 174-175 headspace, 166 for highly reactive materials, 166 maintenance, 167 maximum allowable working pressure, 167

piping, tubing, and fittings, 164, 166, 167, 168, 169 plastic equipment, 168 pressure gauges, 167 records, inspection, and testing, 165, 167, 170-171 relief devices and regulators, shielding, 166, 170, 172, 174, 175, 300 stuffing boxes and gland joints, 166 Teflon tape applications, 165, 168 valves, 166, 167, 168 venting, 167 warning signs, 166 Principal investigators and project managers, 3, 4, 6, 19, 38, 251, 262 (see also Laboratory supervisor) Procedures for working with materials (see also Experiment planning) biohazards, 126-127, 247-248 compressed gases, 140-141 equipment and glassware maintenance, 114-115 explosive and highly reactive materials, 130-140 flammable chemicals, 127-130 highly toxic substances, 122-125 housekeeping, 113-114 information sources, 48 minimizing exposure, 108-113, 124-125 nanomaterials, 141-146 personal behavior, 108 radioactive materials, 127 storage of chemicals, 114 transport of chemicals, 114 Procurement (see Acquisition of chemicals) Publicly owned treatment works (POTW), 196, 202, 204, 278 Pull stations, 121, 127 Putrescible waste, 204, 206, 207, 208 Pyridine, 72, 303, CD Pyrolysis, 73, 136 Pyrophorics, 19, 34, 50, 69, 70, 74, 96, 100, 113, 128-129, 135-136, 141, 145, 159, 233, 291

R

Radiation and radioactive materials (see also Multihazardous waste) absorbed dose, 81-82 acids, 202, 203, 205 aerosols, 204, 208, 221 biological materials, 207-208 clothing and PPE, 80, 127, 162 decay in storage, 203-204, 207, 208, 278 disposal, 202-205, 207-208 filters, 236 hazards, 75, 79-82 procedures for working with, shielding, 81, 82, 127, 203, 234 training requirements, 13 Radio frequency hazards, 75 Raney nickel, 73, 130, 136, 139 Reaction hazard index, 65 Reactivity (see also Explosive and highly reactive hazards; Incompatibility of chemicals; Pyrophorics; Water reactivity; specific compounds) in air, 70, 72, 87, 93, 125, 130, 134, 135, 136, 137, 139, 140, 141, 143, 160, 173 gases 57, 70, 133, 135, 140, 141 glass, 137, 141 hazards, 70 information sources, 52, 65, 304 pressure reactions, 166 storage hazards, 100-101 Receiving chemicals, 21, 79, 89-90, 263, 278, 299 Receiving rooms and loading areas, 89-90, 240, 256 Recycling characterization of wastes for, 187, 190 containers, packaging, and labware, 93-94, 191 energy reclamation, 195-196, general considerations, 92, 93, 192, 194 information sources, 201 manufacturer and supplier role multihazardous waste, 201, 202, 204, 205

nonhazardous solid waste, 192

off-site, 93, 185, 186, 198 characteristic waste, 189-190 accidents, 5, 16, 19, 29, 30, 181, regulations for chemical chemical hazardous waste, 281, 299 hazardous waste, 193-194, 189-191 supervisors, 15, 16, 17, 226, 301 195-196, 277, 300 Chemical Hygiene Plan, 3, 15, TSCA requirements, 279 solvents, 5-6, 84, 93, 185, 192 47, 269, 274, 275, 292-293, Reproductive toxins, 50, 52, 53, Reducing agents, 69, 70, 73, 100, 295, 296 55, 56, 59, 62-63, 86, 97, 101, 130, 133, 138, 139-140, 170 chemicals used in laboratories, 274-275, 290, 291, 293 Refrigerators and refrigeration 270, 273 Resource Conservation and access control, 123, 216 compliance monitoring, 3 Recovery Act (RCRA), 93, alarms on, 216 compressed gases, 114, 164, 189, 190, 193, 194, 196, 201, azo and peroxide storage, 72, 202, 209, 267, 271, 272, 276, 270, 290, 291 277-278 100, 133-134 containers, 21, 94, 103, 191, 194, containers, 154 298, 301 Respirators decommissioning, 253, 254 and culture of safety, 6 inspections, 180 defrosting and cleaning, 21, determining regulatory status procedures and training, 180 of waste, 190-191 types, 179 explosion-proof, 21, 153-154 electrical codes, 149, 150, 151, Respiratory tract, 57, 124, 166, 179 152, 154 flammability hazards, 21, (see also Inhalation hazards) 153-154 emergency preparedness and Risk assessment (see also Hazard food or beverages, 21, 153 response, 6, 272, 299 evaluation) freezer space for samples, 37 employee information and aerosols, 55, 60, 80, 221 labeling of samples, 154 training, 6 airborne contaminants, 219 power loss, 40, 41, 76 empty containers, 191 biohazards, 13, 79, 80, 207, 221 carcinogens, 54, 55, 63-64 safety precautions, 153 and experiment planning, 281-282 control banding, 64-65 sharing between research groups, 216 federal processes, 267 existing control systems, 11 spark-proof, 154 fire codes, 11, 22, 27, 51, 89, explosivity, 70-74, 132 storage management, 97-98, 95, 98, 100, 113, 114, 128, flammability, 65-70 154 151, 154, 214, 216, 243, 270, information sources, 47-49 waste storage in, 207 272-273 review of, 12 limited waste, 190 Registry of Toxic Effects of toxicity, 54, 55, 58-60 Chemical Substances participation in regulatory Risk-Based Performance Standard (RTECS), 59 processes, 267 (DHS), 262 Regulations and legislation (see PCBs, 275-276 also Occupational Safety penalties for violations, 6, 23, S and Health Administration; 267-268 OSHA standards; individual physical hazards, 6 Safety and emergency equipment statutes) radioactive materials, 79, 127, (see also Fire safety accident reporting and record 270, 276, 278 equipment) keeping, 272, 281, 299 rationale for, 267 access to, 15, 27 acquisition of chemicals, 21, 22, relationships between automatic external 278, 299 regulations and standards, defibrillators, 180 268-269 acutely toxic substances, 274, eyewash units and safety 275, 290, 293, 295, 301-302 risk-based performance showers, 15, 27, 28, 29, 34, standards, 89, 259, 261, 270, 113, 117, 118, 121, 122, 125, administration and supervision of laboratories, 279, 280, 281, 273 127, 128, 137, 176, 178, 180, 295 181, 217, 218, 273, 297, 299 shipping, export, and import, 23, 271-272, 278-281 biohazards, 79, 189, 270-271, first aid, 15, 28, 36, 125, 137, 180 272, 276, 278, 280-281 state, 268 building codes, 11, 22, 27, 95, storage, 95 respirators, 178-180 98, 100, 215, 217, 218, 242, training in, 23 shields, 177 253, 272-273 waste management, 6, 271, spill control kits and cleanup, carcinogens, 59, 63, 101, 273, 276-278 275, 290, 293, 302 storage and inspection, 180-181 Reporting academic laboratories, 3

Safety committees, 12, 16-17, 23, safety shields, 74, 108, 172, Sodium bisulfate, 120, 136 176, 177, 187 (see also Face Sodium bisulfite, 134 24-25, 64, 276 Sodium borohydride, 96 Safety rules and policies shields) Shipment and transport (see also Sodium carbonate, 120, 195 general guidelines, 15-17 Sodium cyanide, 54, 56, 60, 260, housekeeping practices, 19-20 Exports and imports) working alone, 17-18 in alcohol, 101 303, CD biological materials, 101, 272, Sodium hydride, CD Safety shields, 74, 108, 172, 176, 278, 280-281 Sodium hydrogen sulfide, 96 177, 187 Scientists with disabilities, 6-7 Sodium hydroxide, 61, 96, 136, carts, 23 Scrubbers, 236 chemicals, within U.S., 280 140, 190, 209, CD containment, 6, 23, 89, 90, 114, Sodium hypochlorate, 96 Security (*see* Laboratory security) Security plans 125, 298 Sodium nitrite, 140 corrosives, 199 Sodium peroxide, 90 elements, 262-263 gas cylinders 111, 114, 168 Solvents (see also specific chemicals) levels of security, 263-264 managing security, 264 information sources, 48 drying, 78, 140 filtration, 84 "materials of trade" training, 264 exemption, 102 flammable, 28, 120 Seismic activity, 35, 36, 70, 95, 96, 97, 100, 168, 199 nanomaterials, 102-104, 280 green chemistry, 85-86 organic compounds, 62, 70, 76, Select agents, 79, 270 regulations, 23, 271-272, Select carcinogens, 55, 59, 63-64, 278-281 93, 111, 112, 136, 138, 139, training, 23 86, 97, 274-275, 290, 291-292 140, 151, 153, 157, 159, 177, waste, 87, 186-187, 193, 194, Sensitizers (see Allergens, 188, 190, 196 198, 199 recycling, 5-6, 84, 93, 185, sensitizers, and allergic reactions) Signage and postings, 39, 250, 298 192 Service animals, 16, 218 Short-term exposure limits spills, 28, 120 stills, 93, 159-160 Sewer discharges, 16, 35, 69, 85, (STELs), 51, 60, 269 134, 145, 149, 153, 185, 186, Showers Southern Building Code Congress International, Inc., 273 n.1 192, 193, 195, 196, 202, 203, air, 244 Spills and releases 204, 206, 207, 208, 209, 210, safety, 15, 27, 28, 29, 34, 113, 222, 232, 276, 278, 300, 301 117, 118, 121, 122, 125, 127, absorbents, 28, 120, 125, 133, 134, 145, 177, 302 Sharps 137, 176, 178, 180, 181, 217, disposal, 58, 111, 114, 206-207 218, 273, 297, 299 acids, 28, 120 Silver and silver compounds, 166, alarms, 35, 82, 124 hazards, 76-77 Shelf life and expiration dates, 167, CD alkalis and bases, 120 21, 22, 92, 100, 101, 112, 125, Skin contact and effects cleanup, 28-29, 120, 280-281 132, 134, 138, 261 absorption of toxins, 55, 58, 60, containment, 120 Shielding 62, 124, 139, 166, 179 debris management, 120 bench shields, 132 airborne contaminants, 179 disposal, 28 blast/explosion, 109, 110, 130, cold and cryogenic substances, emergency planning and response, 28-29, 35, 118, 120, 131, 161, 174 119 chemical hoods, 131-132, 160, corrosives, 58, 61, 111, 135, 141, 121, 280-281 environmental releases, 28 *177,* 187 full-face, 26, 61, 108, 109, 114, emergency response, 118 flammable solvents, 28, 120 131, 132, 138, 144, 162, 173, minimizing, 111-113 highly toxic substances, 29, 120, 273 174, 176 toxic chemicals, 58 Slips and falls, 77, 164 information sources, 28 glass materials, 177, 225, 229, Slot hoods, 220, 237, 238 low-flammability and lowfor magnetic fields, 76 Snorkels, 143, 220-221, 226, 237, toxicity materials, 28 238, 240, 241, 250, 251, 298 mercury, 121 microwave or radio frequency Sodium, 69, 70, 75, 122, 130, 137, policy, 28-29 emissions, 162 139, 140, 159, 178, CD regulations, 281-282 pressure/vacuum reactions, Sodium amide, 72, 140 reporting, 28, 29, 281 166, 170, 172, 174, 175, 300 radiation, 81, 82, 127, 203, 234 Sodium azide, 61, 136, 260, 303, Standards Completion Program, rotating equipment, 160, 162, 52 Sodium bicarbonate, 120, 177 163

Standards for Protection Against Sulfur, 73, 81, 121, 131, 136, 203, exposure routes, 57-58 gases, 57, 85, 122, 140, 172, 190, Radiation (USNRC), 79, 127, 270, 276 Sulfur dioxide, 96, 170, 303, CD 261, 275 Static electric discharges, 22, 23, Sulfuric acid, 61, 69, 73, 96, 120, hazard evaluation, 53-65 69, 113, 128, 129, 132, 168, 139-140, CD information sources, 48, 52 170, 176 Suppression of aerosols, 114, 124, minimizing exposure, 124-125 Stoppers, 133, 154 126, 208, 236, 240, 244, 301, planning experiments, 122-123 302-303 Storage (see also Refrigerators and protocols, 123 Survival kit, 36 risk assessment, 55, 58-60 refrigeration) access control, 21, 22 storage, 101, 125 acids, 20, 96, 97, 98, 99, 100, target organs, 63 T types, 60-65 biosafety cabinets, 75, 80, 126, Teachers and instructors, 3-4 waste disposal, 125 143, 220, 221, 231, 236, 244, Teaching laboratories (see TOXLINE, 53 245-248, 251 Academic laboratories) TOXNET, 52, 53, 63 carcinogens, 97, 101 Technology advances, and culture Tracer gases, 221 of safety, 5 chemical storage cabinets, 22 Training (see Education and clothing and PPE, 113, 175 Temperature sensors and smoke training in safety practices) detectors, 100, 178, 249 cold storage, 21, 97-98 Transfer and exchange of compatibility, 21, 22, 27, 96-97 Teratogens, 52, 62, 275, 291 (see chemicals also Developmental toxicity; compressed gas cylinders, 26, between containers, 23, 84, 87, 94, 104, 113, 123, 125, 35, 90, 96, 100, 111, 114, 154, Reproductive toxins) 164, 166, 168, 170 240-241 Testing containers, 35, 73, 77, 89, 94, 95, with acids, 188, 189 compressed gases, 166 96, 97, 98-99, 100, 113, 114, alarm systems, 43, 193, 245, nanomaterials, 103-104 125, 129, 133, 137, 154, 191, 249, 250 Transport (see Shipment and 192, 302 Tetrahydrofuran, 28, 67, 72, 96, transport) controlled substances. 95 120, 134, 136, 138, 160, CD Trifluoroacetic acid, CD corrosives, 97, 100, 166, 192, Thermometers, 17, 87-88, 157 Trimethylaluminum, CD Titanium, 73, 136 Trimethyltin chloride, CD 221 Titanium dioxide, 49, 78-79, 141 Tubing, 17-18, 76, 115, 128, 137, cyanides, 22 dating, 21 Toluene, 67, 85, 86, 93, 96, 133, 149, 154, 156, 164, 165-166, experiment planning, 125 140, 202, 203, CD 167, 168, 170, 171, 172, 175, flammable and combustible Toluene diisocyanate, 61, CD 176, 237, 239 (see also Hoses) liquids, 22, 98-99 **Toxic Substances Control Act** (TSCA), 279-280 gas cylinders, 100 U general considerations, 95-96, Toxins and toxicity (see also Acute toxicity; Allergens, ULPA (ultra-low penetration air) in glass, 73, 94, 99, 100, 129, sensitizers, and allegic filters, 236, 248 133, 137, 154, 191, 192, 302 reactions; Asphyxiants and Ultrasonic equipment, 85, 86, 149, highly toxic substances, 22, 97, asphyxiation; Carcinogens; 161 101, 125 Chronic toxicity and health Ultraviolet peroxidation, 203, 208 inappropriate places, 21 affects; Corrosives and corrosivity; Developmental Ultraviolet radiation, 72, 75, 76, information sources, 48 toxicity; Exposure; Irritants; 109, 139, 151, 162, 176 inspection, 27 labeling, 21, 51, 94, 154 Neurotoxicity; Reproductive Unattended experiments, 34, 39, odiferous materials, 22 toxins) 40, 41, 42, 116, 124, 128, 149, peroxides, 21, 72, 100, 133-134 access control, 123-124 151, 154, 155, 156, 158, 160, 161, 170, 301 reactive substances, 100-101 compressed gases, 96, 121 regulations, 95 designated areas, 123 Unconscious victims, 119 rooms, 22 dose-response relationship, Uniform Fire Code, 270 54-56 Uniform Hazardous Waste shelving, 21 size of containers, 99 duration and frequency of Manifest, 199, 200 sprinkler head distance, 21 exposure, 56 United Nations emergency planning, 125 Environment Programme, 51 ventilation, 22

337

Recommendations on the Transport of Dangerous Goods, 49 Sub-Committee of Experts on the Transport of Dangerous Goods, 49 Unused and excess material, 73, 86, 87, 114, 133, 185, 192

V

Vacuum cleaners, 121, 145, 302-303 Vacuum systems and operations assembly of apparatus, 175 desiccators, 175 Dewar flasks, 174-175 glass vessels, 26, 74-75, 109, 115, 131-132, 135, 149, 153, 167, 170, 171-172, 174-175 hazards, 74-75 pumps, 153 rotary evaporators, 175 spill cleanup, 121 Valves, gas cylinders, 168, 169 Vapor pressure, 56, 57, 65, 122, 128, 164, 219, 220, 290 Variable autotransformers, 151, 154, 155, 156, 157, 158, 170 Vehicular accidents, 102, 193 Ventilated balance enclosures, 220, 238 Ventilation and environmental control systems (see also Chemical hoods; Exhaust systems) and airborne contaminants, 219, 221, 241, 251, 296, 298 code requirements, 253 choosing, 253 commissioning, 251 constant air volume systems, 241 containers, 139-140 design criteria, 249-250

engineering controls for personal protection, 220 exhaust systems, 241-243 goals performance measurement, 250-251 information sources, 253 inspection, 250 maintenance, 248-249, 250 management program, 249-251 monitoring systems, 252 retrocommissioning, 252 risk assessment, 219-221 supply systems, 179, 180-181, 217, 222, 226, 227, 241 sustainability considerations, 251-253 training program, 250 Venting (see also Exhaust systems) gas cylinders, 168, 170 Vinyl acetylene, 71 Visible radiation, 75 Visitors, 15, 16, 35

W

Waste management (see also Characterization of waste: Chemical hazardous waste; Multihazardous waste) absorbents, 193, 203, 204 academic laboratories, 3 administration and supervision, 209, 302 air emissions, 278 biohazards, 87, 108, 127, 185, 187, 189, 195, 201, 202, 205-208, 278 commingling of waste, 191, 193, 194, 198, 203 containers, 23, 58, 87, 93, 110, 111, 114, 120, 125, 127, 144, 145, 191, 192, 193, 194, 195, 198, 199, 206-207, 209 corrosives, 113, 118, 144, 302

wastes, 153, 174, 190, 191, 192, 199, 209 cost-effectiveness, 5-6 and culture of safety, 5-6 experiment planning, 125 filter disposal, 107, 191, 192 highly toxic materials, 125 information sources, 48 landfill disposal, 185, 190, 193, 194, 195, 196, 197, 300 packaging and shipment, 87, 186-187, 193, 194, 198, 199 radioactive waste, 202-205, 208, 278 reduction/minimization, 5, 6, 85, 86, 108, 195, 201, 202, 203, 207, 277 regulations, 271, 276-278 sewer discharges, 16, 35, 69, 85, 134, 145, 149, 153, 185, 186, 192, 193, 195, 196, 202, 203, 204, 206, 207, 208, 209, 210, 222, 232, 276, 278, 300, 301 sharps, 77, 114, 115, 203, 205 source reduction, 5, 122, 185, 195, 201, 202 treatment (laboratory-scale) of surplus and waste chemicals, 209-210 Water reactivity hazardous materials, 70 Weather, severe, 34-35 Windows, 132, 258 Working alone, 15, 17-18, 116, 120, 122, 301 World Health Organization, 51, 76

X

Xylene, 62, 67, 85, 93, 190, 203

Z

Zirconium, 73, 136