

Heavy Metals, their Salts, and other Compounds

A Quick Reference Guide from AIC and the Health & Safety Committee

A Special Insert By

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PERIODIC TABLE OF THE ELEMENTS

Period	Group IA											Group IIA											Group IIIA	Group IVA	Group VA	Group VIA	Group VIIA	Noble gases												
1	1 Hydrogen H 1.00797											2 Helium He 4.0026											3 Boron B 10.811	4 Carbon C 12.011	5 Nitrogen N 14.0067	6 Oxygen O 15.9994	7 Fluorine F 18.9984	8 Neon Ne 20.183												
2	3 Lithium Li 6.939											4 Beryllium Be 9.0122											13 Aluminum Al 26.9815	14 Silicon Si 28.086	15 Phosphorus P 30.9738	16 Sulfur S 32.064	17 Chlorine Cl 35.453	18 Argon Ar 39.944												
3	11 Sodium Na 22.9898											12 Magnesium Mg 24.312											19 Potassium K 39.102	20 Calcium Ca 40.08	21 Scandium Sc 44.956	22 Titanium Ti 47.90	23 Vanadium V 50.942	24 Chromium Cr 51.996	25 Manganese Mn 54.938	26 Iron Fe 55.847	27 Cobalt Co 58.933	28 Nickel Ni 58.71	29 Copper Cu 63.54	30 Zinc Zn 65.37	31 Gallium Ga 69.72	32 Germanium Ge 72.60	33 Arsenic As 74.922	34 Selenium Se 78.96	35 Bromine Br 79.916	36 Krypton Kr 83.80
4	37 Rubidium Rb 85.447	38 Strontium Sr 87.62	39 Yttrium Y 88.905	40 Zirconium Zr 91.22	41 Niobium Nb 92.906	42 Molybdenum Mo 95.94	43 Technetium Tc (98)	44 Ruthenium Ru 101.07	45 Rhodium Rh 102.905	46 Palladium Pd 106.4	47 Silver Ag 107.870	48 Cadmium Cd 112.40	49 Indium In 114.82	50 Tin Sn 118.69	51 Antimony Sb 121.75	52 Tellurium Te 127.60	53 Iodine I 126.904	54 Xenon Xe 131.30																						
5	55 Cesium Cs 132.905	56 Barium Ba 137.34	57 Lanthanum La 138.91	72 Hafnium Hf 178.49	73 Tantalum Ta 180.948	74 Wolfram (Tungsten) W 183.85	75 Rhenium Re 186.20	76 Osmium Os 190.2	77 Iridium Ir 192.2	78 Platinum Pt 195.09	79 Gold Au 196.967	80 Mercury Hg 200.59	81 Thallium Tl 204.37	82 Lead Pb 207.19	83 Bismuth Bi 208.980	84 Polonium Po (210)	85 Astatine At (210)	86 Radon Rn (222)																						
6	87 Francium Fr (223)	88 Radium Ra (226)	89 Actinium Ac (227)	104 Unnilquadium Unq (261)	105 Unnilpentium Unp (262)	106 Unnilhexium Unh (263)																																		
7																																								

58 Cerium Ce 140.12	59 Praseodymium Pr 140.907	60 Neodymium Nd 144.24	61 Promethium Pm (147)	62 Samarium Sm 150.35	63 Europium Eu 151.96	64 Gadolinium Gd 157.25	65 Terbium Tb 158.924	66 Dysprosium Dy 162.50	67 Holmium Ho 164.930	68 Erbium Er 167.26	69 Thulium Tm 168.934	70 Ytterbium Yb 173.04	71 Lutetium Lu 174.97
90 Thorium Th 232.038	91 Protactinium Pa (231)	92 Uranium U 238.03	93 Neptunium Np (237)	94 Plutonium Pu (242)	95 Americium Am (243)	96 Curium Cm (247)	97 Berkelium Bk (249)	98 Californium Cf (251)	99 Einsteinium Es (254)	100 Fermium Fm (253)	101 Mendelevium Md (256)	102 Nobelium No (253)	103 Lawrencium Lr (257)

*Lanthanide series

*Actinide series

*Numbers in parentheses are mass numbers of the most stable or best-known isotope of radioactive elements.

Figure 1. The 35 shaded elements in this periodic table are those regulated by OSHA under the classification of Heavy Metals [1, 2].

Introduction

The term heavy metal is a loosely used term generally accepted to mean dense metals of relatively high atomic mass, with a specific gravity of 4 or above. Although there are several other definitions of the term there is no specific set of elements that would imply any common set of properties such as high toxicity or high atomic weight [3]. The heavy metals group includes transition metals, some metalloids (elements that exhibit both metal and non-metal properties), some lanthanides and actinides, and often includes reference to certain light and trace metals with an inference to toxicity. An example of the ambiguity of the term heavy metal is that of molybdenum, a heavy but essential trace ele-

ment and beryllium, a light but very toxic metal [4]. All metals are characterized by their excellent ability to conduct heat and electricity (the metalloids being semi-conductors), and are malleable, ductile, hard, and shiny, the exception being mercury which is liquid at room temperature.

One of the most significant factors about metals is their residual persistence over time. Metallic compounds such as oxides, sulfides, chlorides, carbonates, nitrates, and other salts are formed when positively charged metals called cations react with negatively charged elements called anions in ionic or covalent bonds. The resulting metallic compounds can result in very different properties of solubility and toxicity [5]. For example, trivalent chromium, Cr (III), is an essential trace ele-

ment [6] and its compounds, including soluble chromium salts, are considered to be of low toxicity and are thought to present few industrial hazards [22]. Hexavalent chromium, Cr (VI), however, is highly toxic [6] and its compounds, including chromic acid and chromates, are potential carcinogens [22].

Posted on the AIC website, the "Chart of Heavy Metals, their Salts, and other Compounds" provides a quick reference to the 35 elements and some of their compounds classified and regulated by OSHA as heavy metals [1]. Additional compounds often encountered in conservation are also listed. The guide is not definitive or all-inclusive; it is meant to be used in conjunction with other resources. Complete information about each of

their properties, toxicity, and specific compound or additional occupational exposure levels can be found in MSDS sheets, OSHA and NIOSH publications, and other health and regulatory governing agencies found on the Internet and listed at the end of this guide. All health and safe handling guidelines and hazardous waste disposal should be followed as outlined by the various governing bodies; appropriate personal protective equipment (PPE) should be used as described in OSHA regulations with particular attention paid to the use of respirators.

Detection Methods

The appropriate testing method to use for the detection of a specific heavy metal will depend on the answers to some key questions:

- What do you want to know and why?
- What is the material type of the object to be tested?
- Can a sample be taken or must the test be non-destructive?

Regardless of the testing method, test results on homogeneous samples are usually indicative of the entire object, however, results on heterogeneous samples (such as organic substrates) are indicative of the specific test site/sample only. Quantitative results are relevant only for the sample or site tested.

Spot Tests

Spot test procedures are relatively reliable indicators of the presence of residual surface chemicals. They can

provide results ranging from qualitative to semi-quantitative. Some tests are available in pre-packaged test kits. Spot tests can be destructive or non-destructive to the object or surface being tested depending on the method used. They all involve chemical reactions and need to be conducted in a safe controlled environment whether in the laboratory or in the field by trained personnel. Proper waste disposal guidelines for hazardous waste generated from the test procedure should be followed [7, 8].

Analytical Instruments

Hand-held X-ray Fluorescence Spectrometry (XRF) - A surface technique, the XRF analyzer conducts multiple elemental analyses and is considered to be non-destructive to the object. It can be used with swabs, wipes, or in direct contact with the surface. The instrument yields quantitative results for modern metal alloys or soils based on approved NIST industrial standards and calibrations for which the instruments were made. Results on archaeological metals and glass substrates range from qualitative to quantitative; results on organic substrates are presently qualitative, but with appropriate reference materials, instrument calibrations may be able to offer semi-quantitative ranges. The instrument is easy to use but spectrum and data are complicated to interpret, especially on organic substrates because the data alone cannot be relied on for accurate results and spectrum must be interpreted. Trained personnel are necessary for application and accurate interpretation.

The hand-held XRF is an excellent screening tool and can easily be used in storage rooms and exhibition cases, as well as on-site for field archaeology.

Inductively Coupled Plasma Spectroscopy (ICP) - Conducts multiple elemental analyses using a tiny sample that must be dissolved for the analysis (a destructive technique). Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (La-ICP-MS) models have the capability to analyze certain whole objects. The instrument yields highly accurate quantitative results for low levels of elements. It is an excellent tool to crosscheck semi-quantitative to quantitative results of the hand-held XRF [9]. ICP is a laboratory procedure that must be conducted by qualified personnel [7, 10, 11].

Atomic Absorption Spectroscopy (AAS) - Analyzes one element at a time using a tiny sample that must be dissolved for the analysis (a destructive technique). The instrument yields highly accurate quantitative results for low levels of elements. The use of High Performance Liquid Chromatography (HPLC) in conjunction with AAS analysis (used as the detector) can provide speciation of the sample [12.] AAS is a laboratory procedure that must be conducted by qualified personnel [7, 10, 11].

Spark Emission Spectroscopy - A destructive technique that tests mostly solids and is good for bulk constituents [7].

Wet Chemical Techniques - Samples must be dissolved (destructive techniques). Wide variety of possible techniques, titrations, ion-specific electrodes, etc; may be very useful depending on the analyte and levels to be analyzed [7].

Ion Chromatography - Low levels (range of 0.1 ppm) of multiple ions can be determined giving quantitative results. The samples must be dissolved making it a destructive technique [7, 10].

Health and Safety

Unlike industrial workers who are more likely to encounter higher doses of potentially hazardous materials resulting in acute exposure [13], museum workers are more likely to be

List of Acronyms

For a comprehensive lists of acronyms, health agencies and governing bodies refer to the following websites:

- ACGIH:** American Conference of Governmental Industrial Hygienists, www.acgih.org
CDC: Center for Disease Control and Prevention, www.cdc.gov
DHHS: U.S. Department of Health and Human Services, www.os.dhhs.gov
EPA: U. S. Environmental Protection Agency, www.epa.gov
OSHA: Occupational Safety and Health Administration, www.osha.gov
NIOSH: National Institute for Occupational Safety and Health, www.cdc.gov/niosh

Acronyms used in the chart and references:

- CAS:** Chemical Abstract Service (chemical registry number)
MSDS: Material Safety Data Sheets
PEL: Permissible exposure limit - OSHA regulated concentrations
TLV: Threshold limit value - ACGIH suggested concentration guidelines
TWA: Time-weighted average - NIOSH recommended exposure limits (RELs)
ppm: parts per million (conversion factors: parts of vapor or gas per million parts of contaminated air by volume at 25°C and 1 atmosphere)
mg/m3: milligrams per cubic meter (conversion factors: milligrams of vapor or gas per cubic meter of contaminated air at 25°C and 1 atmosphere)

exposed to low-level doses of heavy metals over an extended period of time, resulting in chronic health problems. Heavy metal exposure in the environment along with that from museum collections and buildings is of particular concern to museum professionals involved in emergency and disaster rescue and recovery efforts. Health and safe handling guidelines for specific metals and their compounds have been developed by national and international governing health and environmental agencies and are readily available in electronic form and in numerous hardcopy publications. Institutions in the U.S. are required to follow OSHA health and safety regulations and dispense all known information about existing hazards to personnel and handlers of the materials under OSHA's 1986 Hazard Communication Standard providing employees with the right to know [7].

Personal Protective Equipment (PPE) - Consult OSHA regulations, NIOSH recommendations, and MSDS sheets as well as other resources pertaining to specific PPE required for use with certain hazardous materials and standard lab procedures. Nitrile gloves, lab coats, booties, hair nets, protective suits, dust masks and respirators are standard PPE for use in conservation laboratories. Respirator use is governed by OSHA [14]. Those who need/choose to use respirators must obtain medical clearance, receive use training and have their respirator individually fit tested by authorized testers prior to use. Members of the Health & Safety Committee provide training and fit testing at the annual AIC meetings. All respirators must be NIOSH approved for the specific type of mask, filter, or cartridge needed [14, 15].

Handling and Storage - In general, most objects containing hazardous materials should be kept in a tightly closed container, stored in a cool, dry, ventilated area, isolated from any source of heat or ignition and in an area where it will be protected against physical damage. Do not use or store hazardous materials on porous work surfaces (wood, unsealed concrete, etc.). Follow strict hygiene practices. Containers may be hazardous when empty since they can retain product residues (dust, solids, vapors, liquid);

observe all warnings and precautions listed for the product. Dispose of containers and unused contents in accordance with federal, state and local requirements [16]. Laboratory safety protocol should be followed. MSDS documents must be on the premises in the lab for each substance present. Unless a substance is known to not be hazardous, it should be treated as though it was hazardous.

Documentation- All test results, suspect hazards and known archival information should be documented (written, photo, analytical test results) and filed appropriately (electronically/hard copy) for easy access by personnel who handle the material. All tested objects, shelves, drawers, and storage room doors should be identified as having been tested with clear and concise hazard identification labels or tags, and for an individual item, both the object and the container (polyethylene bag, box) and/or isolated shelf or drawer should be labeled.

A Specific Note About Mercury

Inhalation of mercury vapor is of particular concern if working in an enclosed, not well-ventilated room. Therefore, it is suggested that personnel not work in certain storage areas or the confines of an exhibit case. To retrieve an object suspected or known to be fabricated or contaminated with a mercury compound, it is suggested that the drawer or cabinet where the object is housed be opened and that individuals immediately leave the room for a period of time* without breathing in the air directly in front of or above the housing unit. This will allow any mercury vapor that may have built up in the enclosed drawer or cabinet to be released into the ambient air. Once it is safe to return to the room, remove the object to a well-ventilated area rather than work in the store room if at all possible. The same precaution should be taken when opening an enclosed container to retrieve an object: e.g. open/unseal a bagged object in a fume hood or well-ventilated room, leave the area and return after a period of time* to continue work. When work is completed then re-seal

the container before returning it to the store room [8]. All pertinent PPE should be used throughout the process.

**The specific time interval is unknown as it relates directly to the level of airflow and other factors in the room. Air quality tests can be conducted to determine the time frame using a Jerome 431-X Mercury Vapor Analyzer and a Lumex RA-915+ Multifunctional Mercury analyzer [8].*

A Specific Note About Arsenic as Arsine

Possible exposure to arsine for conservators, collection managers and other museum workers is normally confined to controlled chemical reactions such as in the arsenic spot test. In view of the recent natural disasters that have been occurring, museum workers and disaster recovery teams should be aware that arsine gases can also form as a result of the natural (and complex) biomethylation process undertaken by certain organometallic micro-organisms in the environment [17]. Although highly unlikely to be found in environmentally climate-controlled institutions, it is possible that under certain moisture/ high humidity conditions where mold may form, these micro-organisms could be present and this increases the potential of arsine being present [18, 19]. High levels of methylated arsenic compounds have been found in confined spaces in greenhouses and in relation to arsine poisoning incidents involving the pigment, Paris Green (copper acetoarsenite), in wall paper [17, 20]. Arsine has a subtle garlic odor associated with its presence.

An expanded version of the Heavy Metals Reference Guide is available online through the AIC Health & Safety Committee's webpage. This document includes a chart with an extensive listing of OSHA regulated heavy metals, their salts, and other compounds. This handy reference guide details the physical description, use, occupational exposure limits, and chemical formulae of over one hundred compounds. Visit www.aic-faic.org to download a copy for your lab today.

References:

Note: this section is applicable to the printed text and the on-line chart.

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- Care of ceramics and glass, 5/1
Care of objects made of plaster of paris, 12/2
Mercury in museum collections, 1/7
Care of alum, vegetable, and mineral tanned leather, 8/2
Care of encased photographic images, 16/1
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References include those for the online chart as well as the printed text.

CHART of HEAVY METALS, THEIR SALTS AND OTHER COMPOUNDS

Cheryl Podniki, Conservator, AIC-PA, Health & Safety Committee, November 2008

The 35 capitalized Elements listed on the following chart are those regulated by OSHA as Heavy Metals, including the italicized compounds [1]. Many of the compounds listed can be found in the *NIOSH Pocket Guide to Chemical Hazards and other databases* including *NIOSH* [21], *IDLHC* [22], and *ICSC* [23]. Others can be found in numerous chemical [7, 24-29] and environmental [30] listings, as well as conservation resources [31]. Although conservators may not typically be exposed to some of the OSHA chemicals listed their compounds may be components of complex objects including paper and textiles [8, 32-39], geological collections [36], herbariums [8], cultural property, building structures, or may be present in the environment [40]. The list includes commonly used pigments [5, 41], preservatives and pesticides [5-7, 36, 42-43], mineral sources [5, 6, 24, 31, 36, 43], industrial [45-47] and medically related compounds [5-6, 14-16, 21-23, 45]. The chart serves as a guide only and is not all-inclusive.

Acronyms used in this chart and in references:

CAS: Chemical Abstract Service (chemical registry number)

MSDS: Material Safety Data Sheets

PEL: Permissible exposure limit - OSHA regulated concentrations

TLV: Threshold limit value - ACGIH suggested concentration guidelines

TWA: Time-weighted average - NIOSH recommended exposure limits (RELs)

ppm: parts per million (conversion factors: parts of vapor or gas per million parts of contaminated air by volume at 25°C and 1 atmosphere)

mg/m³: milligrams per cubic meter (conversion factors: milligrams of vapor or gas per cubic meter of contaminated air at 25°C and 1 atmosphere)

For comprehensive lists of acronyms, health agencies and governing bodies refer to the following websites:

ACGIH: American Conference of Governmental Industrial Hygienists www.acgih.org

CDC: Center for Disease Control and Prevention www.cdc.gov

DHHS: U.S. Department of Health and Human Services www.os.dhhs.gov

EPA: U. S. Environmental Protection Agency www.epa.gov

OSHA: Occupational Safety and Health Administration www.osha.gov

NIOSH: National Institute for Occupational Safety and Health www.cdc.gov/niosh

CHEMICAL/ FORMULA / CAS # PHYSICAL DESCRIPTION	SYNONYMS/ TRADE/ MINERAL/ PIGMENTS	USES/ NOTES	OCCUPATIONAL EXPOSURE LEVEL
ALUMINUM (AL) 7429-90-5 Silvery-white, malleable, ductile, odorless metal; silvery-white to grey powder	Aluminium; Aluminum metal; Elemental aluminum; Aluminum powder (aluminum bronze powder) Minerals: Bauxite ore; Feldspars; Cryolite; Alum; Aluminosilicate clays	Construction; building structures; transportation structures; aerospace industry; solid rocket fuels; electrical applications; electrical transmission lines; explosives; pharmaceuticals; medications (e.g. antacids, buffered aspirin); antiperspirants; medical therapy; cooking utensils; aluminum foil; packaging materials; food packaging; beverage cans; food additives; baking powder; processed cheese; cosmetics; “softened” water; tap water; soap; production of glass and ceramics; salts as textile mordents; aluminum powder used to make aluminum leaf for moisture and waterproof paints; geological specimens	OSHA PEL: TWA 15 mg/m ³ (total); TWA 5 mg/m ³ (resp); TWA 2 mg/m ³ (soluble salts). * Human dementia syndromes [6]

<p>alpha-Aluminum oxide 1344-28-1 Al_2O_3 White odorless crystalline powder</p>	<p>Aluminium oxide; Aluminum oxide; Alumina; Aluminum trioxide; Emery powder (natural aluminum oxide) Mineral: Aloxite; Corundum Gem: Ruby (red form of corundum); Sapphire</p>	<p>Single electron transmitters; super conducting devices; hip replacements; polishing and abrasive applications; sandpaper; manufacture of zeolites; fire retardant; smoke suppressant; chromatography medium; sodium vapor lamps; coatings for compact fluorescent lamps; water filters; protective coatings on pre-finished wood floors; billiard chalk; toothpastes; jewelry; glass (beads); pigment coatings; geological specimens</p>	<p>OSHA PEL: TWA 15 mg/m³ (total); TWA 5 mg/m³ (resp) (as Al)</p>
<p>Aluminum hydroxide 21645-51-2 $\text{Al}(\text{OH})_3$ Odorless white powder in various forms</p>	<p>Alumina hydrate; Aluminum oxide trihydrate; Trihydroxyaluminum; Transparent White Mineral: Bauxite</p>	<p>Transparent White is used in preparation of transparent lake pigments; filler for paints</p>	<p>TLV not established</p>
<p>Aluminum Indigo Carmine 12225-21-7 $\text{C}_{16}\text{H}_9\text{AlN}_4\text{O}_9$ Yellow-greenish powder</p>	<p>Trade names: C.I. Pigment yellow 100; C.I. 19140 Aluminum Lake; C.I. Food Yellow 4 Aluminum Lake; FD & C Yellow No. 5 Aluminum Lake; Japan Food Yellow 4 Aluminum Lake; Lakeolene B 3014; Pigment Yellow 100; Tartrazine Aluminum Lake; Yellow Lake T</p>	<p>Azo dye complex; pigments</p>	<p>TLV not established * Azo, Diazo, and Azide compounds can detonate</p>
<p>Aluminum silicate clay, Bentonite 1302-78-9 (Calcium or sodium bentonite) Fine, natural clay, granules or powder in variable colors (decomposition of glass particles in volcanic ash)</p>	<p>Colloidal clay; Soap clay; Mineral soap; Gumbrin Mineral: Montmorillonite Trade names: Fuller's earth; American clay; Wilkinite</p>	<p>Calcium bentonite: Absorbent clay; poultices Sodium bentonite: Water softener; emulsifier in Portland cement and concrete; increases plasticity in ceramic clay body; filler in insecticides, soaps, paper and paints</p>	<p>TLV not established</p>
<p>Aluminum stearate 637-12-7 $\text{Al}(\text{C}_{18}\text{H}_{35}\text{O}_2)_3$ Hard thermoplastic white powder</p>	<p>Stearic acid aluminum salt; Aluminum (III) stearate; Octadecanoic acid aluminum salt; Daiwax WA1; Metaspa XX; Rofob 3</p>	<p>Soap made by saponification of tallow and treatment with alum; photographic emulsion; waterproofing agent for fabrics, ropes, paper, leather, concrete, and stucco; flattening agent in varnishes and lacquers; forms colloidal solutions or gels with oils, turpentine, mineral spirits; paint and varnish drier, thickener, and emulsifier; artist's oil pastes and prepared paints</p>	<p>OSHA PEL: TWA 15 mg/m³ (total); TWA 5 mg/m³ (resp); TWA 2 mg/m³ (soluble salts) (as Al)</p>
<p>Aluminum sulfate 10043-01-3 $\text{Al}_2(\text{SO}_4)_3$ Odorless white crystals or powder. Note: Aluminum sulfate is the general group name used to refer to as alum. Alum compounds include hydrated double salts usually consisting of aluminum sulfate, water, and a sulfate of another element e.g. potassium, sodium, ammonium, selenium, selenate (the first three being the most common, respectively)</p> <p>Potassium aluminum sulfate 7784-24-9 $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ White crystals or powder</p> <p>Aluminum ammonium sulfate $\text{AlNH}_4(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ White crystalline powder</p>	<p>Aluminum sulphate; Aluminum trisulfate; Aluminum (III) sulfate; Aluminum sesquisulfate; Fertosan; Aluminum alum; Alum; Alumen; Filter alum; Cake alum; Cake aluminum; Cube alum; Alumstone; Alum flour; Alum meal; Kalinite; Paper maker's alum; Patent alum; Pearl alum; Pickle alum; Sulfuric acid Aluminum (3) salt (3:2); Tai-Ace S150; NALCO 7530 Mineral: Alunogenite</p> <p>Alum (most common alum compound); Native alum; Potash alum; Alumina; Alumnus; Alumnae; Alurni; Bitter salt Mineral: Alunite; Acuminite Naturally occurring: Potash alum</p> <p>Ammonia alum; Ammonium aluminum sulfate Mineral: Tschermigite</p>	<p>General uses of Alum compounds: Flocculating agent used to clarify water in gel precipitate of aluminum hydroxide; water purification; sewage treatments; medicinal as an astringent to prevent bleeding (e.g. styptic pencil), adjuvant to enhance immune response in human immunizations, antibacterial agent, antiseptic, emetic, home remedy for canker sores; make-up as a skin whitener; aftershave; wax for hair removal; hair stiffener; natural (crystal) deodorant; food pickling (as a preservative); food additive; some playdough recipes; fire retardant; foamite used in fire extinguishers for chemical and oil fires; leather tanning hardener for gelatin, plastic, cement; filler in paper, cement, paints; paper sizing; mordant in textile dyeing; preparation of lake pigments; geological specimens</p> <p>Developing baths for black and white photography; baking powder; textile dyeing; leather tanning; substrate for lake pigments</p>	<p>NIOSH REL: TLV: 2 mg/m³ (as Al soluble salts) (ACGIH 1993-1994)</p>

Kaolin 1332-58-7 Mainly hydrous aluminosilicate $H_2Al_2Si_2O_8 \cdot H_2O$ White powder	Hydrated aluminium silicate; China clay; Argilla Trade names: Kaolin; Kaolite Mineral: Kaolinite	Commercial cleaning of fabrics, furs and carpets; porcelain production; filler in paints, pastels, papers, rubbers, cements; abrasives; absorbent for oils and grease; base for Lake pigments	NIOSH REL: TWA 10 mg/m^3 (total); TWA 5 mg/m^3 (resp)
Sodium aluminum fluosilicate 53404-77-6 $Na_5Al(SiF_6)_4$ White powder	Silicate hexafluoro-aluminum sodium Trade names: Larvex; Larvex mothproofing Composition; Selig's Fabriteks (W)	Insecticide; mothproofer (discontinued 1930's); buffer in dye baths	OSHA PEL: TWA 2.5 mg/m^3 . The PEL applies to other solid fluorides (as F)
Sodium fluoroaluminate 15096-52-3 Na_3AlF_6 Natural Cryolite mineral: white solid or powder; Synthetic: pink or brown tinted granular powder	Sodium aluminum fluoride; Sodium aluminofluoride; Sodium hexafluoroaluminate; Synthetic Cryolite Trade Names: Cryocide; Cryodust; Cryolite; Kriolit; Kryocide; Kryolith; Prokil Mineral: Cryolite	Used as a flux in solvent for bauxite in electrolytic production of aluminum; filler for bonded abrasive; enamel and glass production; insecticide	OSHA PEL: TWA 2.5 mg/m^3 (as F)
Sodium fluorosilicate 16893-85-9 Na_2SiF_6 White powder tinted blue; white granular powder	Sodium silicofluoride; Disodium hexafluorosilicate; Sodium hexafluorosilicate Trade Names: Larvex; Larvex mothproofing; Earwig bait	Fluoridation agent for drinking water; glue; flotation; gelling agent in production of molded latex foam; production of enamels and enamel frit for china and porcelain; leather and wood preservative; insecticide, rodenticide; mothproofer (discontinued 1930's) All pesticidal products canceled by early 1990's.	OSHA PEL: TWA 2.5 mg/m^3 (as F)
ANTIMONY (Sb) 7440-36-0 Silver-white, lustrous, hard, brittle solid; scale-like crystals; or a dark-gray, lustrous powder. *Metalloid; semi-metal. On contact with acids may emit toxic gas, Stibine	Antimony metal; Antimony powder; Antimony black; Antimony regulus; Stibium; C.I. 77050 Mineral: Boulangerite; Bournite; Bournonite; Cerrantite; Cerrusite; Jamisonite; Kermasite; Livingston; Polybasite; Pyragyrite; Scorodite; Senarmonite; Stephanite; Stibiconite; Stibnite; Tetrahedrite Often found in trace amounts in ancient copper and lead alloys	Air pollution from industrial emissions; medicinal purposes; cosmetics; metal alloy; plumbing; diodes, infrared detectors; cable sheathing; small arms; tracer ammunition; solder; linotype printing machines; pewter ware; flame retardant; safety matches; fireworks; batteries; bullets; decorative metal; silver amalgams such as in early mirror production; forensic residue on archival materials; toys; incense burners; jewelry coatings; ceramics; enamels; glassware; pigments; weighted silks; geological specimens	OSHA PEL*: TWA 0.5 mg/m^3 . *Note: The PEL also applies to other antimony compounds (as Sb) Toxicity is similar to arsenic poisoning [5] Minor toxic metal [6]
Antimony oxide 1309-64-4 Sb_2O_3 White crystalline powder	Antimony trioxide; Antimony sesquioxide; Antimony (III) oxide; Diantimony trioxide; Flowers of antimony Trade names: Antimony bloom 100A; Atox B; Atox F; Bluestar RG; Bluestar Z; Fire Shield H; Thermoguard B. Minerals: Senarmonite, Valenitinite Pigment: Antimony White pigment (synthetic: antimony and barium sulfate); Trade name: Timonox (1919)	Flame retardant; fiberglass composites; opacifying agent for glass, ceramics, enamels; pigments; geological specimens	OSHA PEL: TWA 0.5 mg/m^3 (as Sb) Antimony white: OSHA PEL: TWA 0.5 mg/m^3 (as Sb) (as Ba) *Carcinogenic [31]
Antimony sulfide 12627-52-0 Sb_2S_3 Odorless orange and red to black crystalline solid	Antimony sulphide; Sulfide of antimony; Antimonial glass; Vitreous antimony Mineral: Stibnite (Source of natural black pigment: Antimony Black; black powder also called Kohl) Pigment: Antimony vermilion (precipitate of antimony chloride and sodium thiosulphate or hydrogen sulfide to give orange-deep red globules)	Pigment used in rubber industry; colorant in ruby glass; pigment is fugitive and unstable in paints Antimony black: Camouflage paints Kohl: Eye paint in Egypt (Amarna period); also used to blacken edges of books since late 17 th century	OSHA PEL: TWA 0.5 mg/m^3 (as Sb)

		Antimony sulfide gives red hue; antimony trisulfide gives orange hue	Antimony oxide sulfide: 19 th century red pigment	
Antimony trisulfide Sb ₂ S ₃ (same formula as antimony sulfide) Red-orange crystalline solid	1345-04-6	Antimony (III) sulfide; Antimony sulfide; Antimony orange; Antimony red; Antimony vermilion; Antimony black; Hermus mineral Pigment: Antimony vermilion (orange hue)	Fireworks; matches; colorant in ruby glass	OSHA PEL: TWA 0.5 mg/m ³ (as Sb)
Stibine SbH ₃ Colorless toxic gas with a disagreeable odor like hydrogen sulfide (rotten eggs); may be formed in etching; welding; or battery charging	7803-52-3	Antimony hydride; Antimony trihydride; Hydrogen antimonide	Production of semi-conductors; fumigant	Stibine: OSHA PEL: TWA 0.1 ppm (0.5 mg/m ³) *Highly toxic gas; causes hemolysis [6]
ARSENIC (As) Metal: Silver-gray or tin-white, brittle, odorless solid. Note: OSHA considers "Inorganic Arsenic" to mean copper acetoarsenite & all inorganic compounds containing arsenic except arsine. *Metalloid; semi-metal	7440-38-2	Arsenic metal: Arsenia; Grey arsenic Minerals: Adamite; Annabergite; Arsenopyrite; Arsenolite; Caludetite; Cobaltite; Conichalcite; Enargite; Erythrite; Finnemanite; Georgiadesite; Glaucodot; Heliophyllite; Koettigite; Legrandite; Loellingite; Mimetite; Miccolite; Nickeline; Olivenite; Orpiment; Pharmacooite; Proustite; Realgar; Schultenite; Skutterudite; Tennantite	Environmental emissions from smelting industries; copper alloys; war gases; homicidal and suicidal weapon; semi-conductors for integrated circuits in supercomputers and cell phones; taxidermy; cell tissue preservative and fixative; human embalming fluid (1850's-1910); fungicides; herbicides; insecticides; pesticides; cosmetics; medicinal purposes; colorant in enamel and glass production (archaeological, contemporary imported glass beads); old wall paper; mordant in textiles; weighted silks; pigments; antifouling paints; geological specimens	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ PEL limits are same for all As compounds unless otherwise noted Major toxic metal [6]. *Carcinogen; suspect mutagen
Arsenic pentoxide As ₂ O ₅ White deliquescent crystals	1303-28-2	Arsenic (V) oxide; Arsenic anhydride; Arsenic acid anhydride	Glass manufacturing; textile dyeing and printing; fungicide; insecticide	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Arsenic sulfide AsS / As ₂ S ₂ / As ₂ S ₄ Translucent to transparent orange-red to yellow-orange crystals	56320-22-0 1303-32-8	Sulphide of arsenic; Arsenic disulfide Mineral and Pigment: Realgar Pigment: Realgar; Red arsenic sulfide; Arsenic red; Red orpiment; Ruby sulfur; Burnt orpiment; Arsenic orange Unstable: Realgar will transform into <i>Pararealgar</i> on exposure to light and turn yellow-orange in color; See Arsenic trisulfide for Orpiment (decomposition product of Realgar)	Fireworks; leather tanning and de-hairing; arsenical paper (e.g. wallpaper, flypaper) used to print calico textiles; pigments; geological specimen	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Arsenic trichloride AsCl ₃ Colorless, oily, fuming liquid with pungent odor	7784-34-1	Arsenic III chloride; Arsenous chloride; Arsenious chloride; Caustic arsenic chloride; Fuming liquid; Butter of arsenic	Fumigant; insecticide	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Arsenic trioxide As ₂ O ₃ White or transparent lumps or crystalline powder	1327-53-3	Arsenic (III) oxide; Arsenous oxide anhydride; White arsenic; Arsenous acid anhydride; Arsenic sesquioxide; Arsenous trioxide; Arsenic glass; White alum (prior to 1800)	Tissue preservative in taxidermy and natural history specimens; human embalming fluid (1850's-1910); arsenic compound most often used on collections in various pesticide solutions, pastes, soap, sprays; colorant in enamels and paints	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Arsenic trisulfide As ₂ S ₃ Lemon yellow to orange-yellow crystals	1303-33-9	Arsenic (III) sulfide; Yellow arsenic sulfide; Arsenic yellow; Arsenous sulfide; Arsenious sulfide; Auripigment	Fireworks; manufacture of infrared transmitting glass; arsenical paper (e.g. wallpaper, flypaper); leather tanning and de-hairing; used to print calico textiles;	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)

		Mineral: Orpiment (decomposition product of Realgar) Pigment: Orpiment; King's Yellow (synthetic 18 th century pigment); Pigment yellow 39; C.I. 77085; C.I. 77086	pigments; geological specimens	
Arsine AsH ₃ Colorless highly toxic gas with a mild, garlic-like odor	7784-42-1	Arsenic hydride; Arsenic trihydride; Arseniuretted hydrogen; Arsenous hydride; Hydrogen arsenide	By-product of refining of non ferrous metals and manufacture of arsenicals when inorganic arsenic is exposed to nascent (freshly formed) hydrogen; chemical reaction occurs in an arsenic spot test; produced by specific organometallic micro-organisms found in the environment	OSHA PEL: TWA 0.05 ppm (0.2 mg/m ³) NIOSH REL: 0.002 mg/m ³ , 15-minute CEILING *Highly toxic gas; causes hemolysis [6]
Gallium arsenide GaAs Grey cubic crystals	1303-00-0		Semi-conductor devices; integrated circuits; laser diodes; solar cells; mobile phones; field transistors; satellite communication; microwave point to point links; some radar systems; electronics; photo mixing	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Iron arsenosulfide FeAsS Silver-white crystals or masses		Iron arsenopyrite; Pyrite; Arsenical pyrite; White metal; Mispickel Mineral: Arsenopyrite (ore of arsenic)	Geological specimens	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Potassium arsenate KH ₂ AsO ₄ Colorless or white crystals or powder.	7784-41-0	Arseniate of potash; Macquer's salt; Potassium dihydrogen arsenate; Potassium arsenate, monobasic; Potassium acid arsenate	Analytical reagent; insecticide; hide preservative; textile printing	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Potassium arsenite KAs ₂ HO ₄ White hygroscopic powder	10124-50-2	Arsenious acid, potassium salt; Arsenenous acid, potassium salt; Potassium metaarsenite; Fowler's Solution (in solution)	19 th century medicinal (coughs, emphysema, skin diseases); pesticide	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Sodium arsenate AsH ₃ O ₄ · xNa Colorless to white crystals or powder	7631-89-2	Arsenic acid, disodium salt; Sodium arsenate dibasic; Disodium arsenate heptahydrate; sodium metaarsenate; Sodium orthoarsenate Trade Name: Sweeny's Ant-go; Fatsco Ant Poison Arsenic acid disodium salt; Disodium arsenate; Disodium hydrogen arsenate	Insecticide	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
Sodium arsenate dibasic AsHNa ₂ O ₄ Colorless to white crystals or powder	7778-43-0	Trade Name: Jones Ant Killer	Insecticide	
Sodium arsenite NaAsO ₂ White granular crystals	7784-46-5	Arsenous acid, Sodium arsenite; Sodium metaarsenite; Arsenous acid sodium salt Trade names: Atlas A; Chem Pels C; Chem-Sen 56; Kill-All; Penite; Prodalumnol; Prodalumnol Double; Sibur; Sodanit	Antiseptic; preservative for hides; herbicides; insecticide; dye making <i>Siburizing</i> refers to its use as a mothproofing	OSHA PEL: [1910.1018] TWA 0.01 mg /m ³ (as As)
BARIUM (Ba) Yellowish to white lustrous solid in various forms	7440-39-3		Metal alloys; superconductors; spark plug wires; ammunition; analytical catalyst; radiopaque aid in x-rays; infrared applications; fireworks; soap; paper; plastic; rubber; ceramics; glass; pesticides; fillers; pigments; paints; geological specimens	OSHA PEL: TWA 0.5 mg /m ³ . *Note: The PEL also applies to other soluble barium compounds (as Ba) *Minor toxic metal [6]
Barium acetate Ba(C ₂ H ₃ O ₂) ₂ ·H ₂ O	543-80-6	Barium diacetate	Mordant in textile dyeing; drier for paints and varnishes	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)

White crystalline powder			
Barium carbonate 513-77-9 BaCO ₃ White powder	Barium monocarbonate; Carbonic acid barium salt Mineral: Witherite Pigment: C.I. Pigment white 10; C.I. 77099	Pesticide; rodenticide; production of bricks; mortar; synthetic marble; glassmaking; pigment in paints and glazes; geological specimens Barium carbonate is a precipitate from barium hydroxide (alkalizing agent) and carbon dioxide for use as alkaline reserves in paper	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium chloride 10361-37-2 BaCl ₂ Odorless white crystals	Barium dichloride	Pesticide; leather tanning; mordant for acid dyes	OSHA PEL*: TWA 0.5 mg/m ³ (as Ba)
Barium chromate 10294-40-3 BaCrO ₄ Yellow powder (a Chromium (VI) compound [5])	Chromic acid barium salt Pigments: Barium yellow; Lemon yellow; Strontium yellow; Ultramarine yellow; Lemon chrome; Permanent yellow; Baryta yellow; Steinbuhl yellow; Pigment yellow 31	Metal primers; anti-corrosion pastes; colorant for glass and ceramic glazes; pigments	OSHA PEL: TWA 0.5 mg /m ³ (Ba); OSHA PEL: TWA 0.5 mg /m ³ (Cr)
Barium copper silicate Blue crystals: BaCuSi ₄ O ₁₀ Purple crystals: BaCuC ₂ O ₆	Han blue; Han purple; Chinese blue; Chinese purple	Pigment in paints and ceramics glazes from Han dynasty (208 BCE-220 CE)	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium hydroxide 17194-00-2 Ba(OH) ₂ White crystalline powder	Barium hydrate; Caustic baryta	Corrosion inhibitor; used to remove sulfates in water; fungicide; insecticide; rodenticide; manufacture of glass and ceramic glazes; aqueous and non-aqueous neutralization and alkalization in paper; Baynes-Cope process (in methanol); cellulose stabilizer	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium hydroxide, monohydrate 22326-55-2 BaH ₂ O ₂ · H ₂ O White powder		Production of other barium chemicals; production of lubricating and oil additives; water purification	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium nitrate 10022-31-8 Ba(NO ₃) ₂ White crystals/fused mass		Oxidizing agent; rodenticide; green fireworks; green signal lights; manufacture of glass and ceramic glazes	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium oxide 1304-28-5 BaO Yellowish-white solid in various forms	Barium monoxide; Barium protoxide; Calcined baryta; Heavy earth	Coating for electrodes of fluorescent lamps; dehydrating agent; glazes; pigments	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium sulfate 7727-43-7 BaSO ₄ Odorless, white or yellowish crystals or powder	Barium sulphate; Artificial barite Minerals: Barite; Barytes, Heavy spar. Pigments: Barite; Barytes, Heavy spar Blanc fixe; Artificial barite; Barium white; Permanent white; Baryta white; Pigment white 21; C.I. 77120 (synthetic); Bologna white; Permalba	Petroleum production; radiocontrast agent for x-ray imaging; filler and extender in paper, wallpaper, linoleum, oil cloth, rubber, plastics, flannel, shoddy cloth; production of lithopone pigments (with ZnS); pigments; geological specimens	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium sulfide 21109-95-5 BaS Pale grey powder	Barium sulphide; Lapis solis; Barium monosulfide; Black ash; Bolognian phosphorus; Bologna stone	Vulcanized rubber; de-hairing hides; the first synthetic phosphor; pigment in luminous paints	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
Barium thiocyanate	Barium sulfocyanide	Photographic solutions; textile dyeing	OSHA PEL: TWA

Ba(SCN) ₂ ·2H ₂ O White needle shaped crystals			0.5 mg /m ³ (as Ba)
Barium thiosulfate BaS ₂ O ₃ ·H ₂ O White crystalline powder	Barium hyposulfite; Barium thiosulphate	Photographic solutions; textile dyeing; pigments	OSHA PEL: TWA 0.5 mg /m ³ (as Ba)
BERYLLIUM (Be) 7440-41-7 Grey to white powder	Glucinium Mineral: Behoite; Bertrandite; Beryl; Bromellite; Crysoberyl; Euclase; Gadolinite; Milarite; Phenakite Gems: Aquamarine Beryl (Be ₃ Al ₂ Si ₆ O ₁₈); Emerald (Be ₃ Al ₂ SiO ₆);	Air emissions from combustion of coal and oil, from beryllium extraction plants, from industrial uses such as ceramic production and beryllium alloy manufacture, and from cigarette smoke; metal alloys; free metal in nuclear reactions; nuclear weapons; missile fuels; space vehicles; space optics; space telescope mirrors; communication satellites; semi-conductors; tweeter and loud-speaker construction; spot-welding electrodes; springs; x-ray detectors in analytical instruments; output windows for x-ray tubes; fluorescent light tubes; geological specimens; gemstones	OSHA PEL: 0.002 mg/m ³ TWA; 0.005 mg/m ³ CEILING. Major toxic metal [6] *Probable carcinogen [5]
Beryllium oxide 1304-56-9 BeO Refractory white powder	Beryllia, Beryllium monoxide	Electrical installation; abrasive for polishing hard metals; manufacture of glass, ceramics, glazes	TLV (as (TWA)): ppm; 0.002 mg/m ³ A1 (ACGIH 1999)
BISMUTH TELLURIDE (undoped) 1304-82-1 Bi ₂ Te ₃ Gray, crystalline solid.	Bismuth sesquittelluride; Bismuth telluride; Bismuth tritelluride Minerals: Tellurobismuthite; Tetradyomite; Bismuthinite	Semi-conductors; pharmaceuticals; medical therapy; cosmetics	OSHA PEL: TWA 15 mg/m ³ (total); TWA 5 mg/m ³ (resp)
BORON (B) 7726-95-6 Amorphous brown powder; black crystals *Metalloid; semi-metal		Brazing alloys; semi-conductors; aircraft and space applications; rocket propellant; fibers and filaments in composites; epoxy resins; ceramics; glass; metals; fabrics; tissue cell preservative; pesticide; oxygen scavenger; laundry soap	OSHA PEL: TWA 15 mg/m ³ ; varies
Borax 1303-96-4 B ₄ O ₇ ·Na ₂ · 10H ₂ O White crystals or crystalline powder	Sodium borate, decahydrate; Disodium tetraborate decahydrate; Sodium tetraborate decahydrate; Sodium pyroborate decahydrate; salt of Boric acid; Trade Names: Jaikin, Pyrobor, Three Elephant, V-Bor Mineral: Borax	Gold extraction; anti-corrosion systems; adhesive manufacture; water softener; bactericides; germicides; anti-fungal compound for fiberglass; insecticide; tissue cell preservative; absorbent for natural history specimens; detergents; cosmetics; fire retardant; enamel glazes; buffering agent; curing agent; flux; drying agent; food additive (outside U.S.)	TLV: 1-5 mg/m ³ (ACGIH 1996)
Boric acid 10043-35-3 B(OH) ₃ Odorless, colorless crystals or white powder	Boracic acid; Orthoboric acid; Acidum boricum Trade Names: Borid; Drax Ant Killer; It Works; Mop-up Mineral: Sassolite	Controls fissure rate of uranium in nuclear power plants; flat panel displays; component in original Silly Putty®; flame retardant; textile fiberglass; antiseptic; anti-bacterial; eye drops; cell tissue preservative; curing agent for hides and skins; insecticide (roaches, silverfish); wood preservative; ceramic production; jewelry manufacture	TLV not established
Decaborane 17702-41-9 B ₁₀ H ₁₄ Colorless to white crystals; strong musty or bitter odor or characteristics sweet chocolate odor of	Boron hydride; Decaboron tetradecahydride	Boron containing thin film; rocket fuel	OSHA PEL:TWA 0.3 mg/m ³ (0.05 ppm) skin

<p>Decaborane 17702-41-9 $B_{10}H_{14}$ Colorless to white crystals; strong musty or bitter odor or characteristics sweet chocolate odor of Boranes</p>	Boron hydride; Decaboron tetradecahydride	Boron containing thin film; rocket fuel	<p>OSHA PEL:TWA 0.3 mg/m³ (0.05 ppm) skin</p> <p>Note: Explosive with carbon tetrachloride</p>
<p>Diborane 19287-45-7 B_2H_6 Colorless compressed gas; characteristics sweet chocolate odor of Boranes</p>	Borane; Boroethane; Boron hydride; Borane hydride; Diboron hexahydride; Hydrogen boride	Reducing agent; doping agent for production of semi-conductors; rocket propellant; flame speed accelerant vulcanized rubber	<p>OSHA PEL: TWA 0.1 ppm (0.1 mg/m³)</p>
<p>Pentaborane 19624-22-7 B_5H_9 Colorless liquid with pungent odor similar to garlic, acetylene or sour milk</p>	Pentaboron nonahydride	Initial experiments for rocket and jet fuel but was unsuccessful due to high toxicity* and spontaneous combustion	<p>OSHA PEL: TWA 0.005 ppm (0.01 mg/m³) *Similar to nerve agents</p>
<p>CADMIUM (Cd) 7440-43-9 Soft blue-white metal lumps or grey powder. Malleable; turns brittle on exposure to 80°C and tarnishes on exposure to moist air</p> <p>Cadmium fume (as Cd) 1306-19-0 CdO/Cd Odorless, yellow-brown, finely divided particulate dispersed in air</p>	<p>Cadmium metal, dust, powder Minerals: Hawleyite; Monteponite</p> <p>Cadmium monoxide; Cadmium oxide fume; Cadmium; Cadmium (II) oxide</p>	Emissions released into environment from ore smelting operations, from mist from cadmium-containing electroplating baths, from calcination (drying) of cadmium pigments, and from handling of powdered cadmium oxide in production of cadmium soaps (used to stabilize plastics); cadmium electrodes; electroplating; nickel-cadmium batteries; bearings; solder alloys; metal coatings; metal alloys; silver alloys; PVC stabilizers; television tubes; semi-conductors; fertilizers; cigarette tobacco; neon sculptures; phosphors; incandescent light filaments; former veterinarian treatment for worms and parasites; colorant in ceramic glazes and glass; pigment in phosphors	<p>OSHA PEL: TWA 0.005 mg/m³</p> <p>The PEL applies to all Cadmium compounds (as Cd) unless noted.</p> <p>Major toxic metal [6]. *Known/Probable Carcinogen</p>
<p>Cadmium acetate 543-90-8 $Cd(CH_3CO_2)_2$ Colorless crystals with characteristic odor</p>	Acetic acid, cadmium salt; Bis(acetoxy) cadmium; cadmium acetate dihydrate	Fungicides for turf and tree bark (discontinued)	<p>TLV: 0.01 mg/m³ (as Cd) A2 (ACGIH 2001)</p>
<p>Cadmium chloride 10108-64-2 $CdCl_2$ White crystalline solid</p>	<p>Cadmium Dichloride; Dichlorocadmium Trade Name: Caddy; Vi-CAD</p>	Analytical agent; photography; fungicides for turf and tree bark; fabric printing	<p>TLV: ppm; 0.01 mg/m³ (as TWA) (as Cd); total dust A2 (ACGIH 1993-1994). TLV (as TWA): ppm; 0.002 mg/m³ (as Cd); respirable dust A2 (ACGIH 1993-1994)</p>
<p>Cadmium sulfate 10124-36-4 $CdSO_4$ Odorless white solid</p>	<p>Cadmium sulphate Trade Names: Cad-Trete; CragTurf Fungicide; Kromad; Miller 531</p>	Fungicides for turf and tree bark	<p>TLV (as TWA): ppm; 0.01 mg/m³ (as Cd), A2 (ACGIH 1998)</p>
<p>Cadmium sulfide 1306-23-6 CdS Light yellow or orange crystals/ yellow to brown powder</p>	<p>Cadmium monosulfide Mineral: Greenockite; Hawleyite Pigment Trade names: Cadmium yellow; C.I. Pigment yellow 37; Cadmium golden 366; Cadmium lemon yellow; Cadmium orange; Cadmium primrose 819; Cadmium yellow 10 G conc; Cadmium yellow conc</p>	Coatings on photovoltaic cells; pigments	<p>TLV: 0.01 mg/m³ (as Cd), A2 (ACGIH 1996)</p>

Anhydrous cobalt phosphate $\text{Co}_3(\text{PO}_4)_2$ or Anhydrous cobalt arsenate $\text{Co}_3(\text{AsO}_4)_2$ or a mixture of the two. Transparent red-violet crystals	Pigment: Cobalt violet	Pigment	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997); OSHA PEL: [1910.1018] TWA 0.01 mg/m ³ (as As)
Cobalt aluminate $\text{CoO} \cdot \text{Al}_2\text{O}_3$ Blue crystals	Cobalt (II) oxide-aluminum oxide Pigments: Azure blue; C.I. 77346; Cobalt blue; Cobalt ultramarine; Dresden blue; Hungary blue; King's blue; Leyden blue; Olympia blue; Pigment blue 28; Thénard's blue (also made with cobalt phosphate and aluminum); Vienna blue; Vienna ultramarine	Cobalt blue filter in ophthalmoscopes; ceramic glazes; colorant for glass, enamels; pigments; 19 th century replacement pigment for smalt and ultramarine	OSHA PEL: TWA 0.1 mg/m ³ ; TLV: 0.05 mg/m ³ (as Co)
Cobalt (II) chloride 7646-79-9 CoCl_2 Pale-blue, hygroscopic powder, turns pink on exposure to moist air	Cobalt dichloride; Cobalt muriate; Cobaltous chloride; Cobaltous Dihydrate; Cobaltous Hexahydrate	Pale blue leaflets that turn pink upon exposure to moist air; added to Silica gel as an indicator of effectiveness as a desiccant due to color change	OSHA PEL: TWA 0.1 mg/m ³ ; TLV: 0.05 mg/m ³ (as Co)
Cobalt (III) oxide 1308-04-9 Co_2O_3 Black-gray crystalline powder	Dicobalt trioxide; Cobalt sesquioxide; Cobalt trioxide; Cobaltic oxide; Cobaltous oxide Pigment: Smalt (early pigment in glass) Trade name: C.I. 77323	Glass; background for gold lettering on signs; pigment (frequently found on old paintings)	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997)
Cobalt oxide (CoO) and Zinc oxide (ZnO) Semi-transparent blue-green crystals	Pigment: Cobalt green (Zinc green, Rinmann's green)	Colorant in ceramic glazes and (cobalt) glass, enamels; pigments	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997) OSHA PEL: TWA 5.0 mg/m ³ (fume); TWA 15 mg/m ³ (total dust); TWA 5 mg/m ³ (resp dust) (as Zn)
Cobaltous ammonium sulfate $\text{CoSO}_4 \cdot (\text{NH}_4)\text{SO}_4 \cdot 6\text{H}_2\text{O}$ Ruby red crystals		Cobalt plating; colorant in enamels, ceramic glazes and glass	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997)
Cobaltous stannate 12019-07-7 $\text{CoO} \cdot n\text{SnO}_2$ Blue-green crystals	Cobalt (II) stannate; Cobalt stannate; Cobalt tin oxide; Pigment blue 35 Pigment: Cerulean Blue; C.I. 77346; C.I. 77368; Coeruleum	Drier for oil paints; pigments	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997)
Potassium cobaltinitrite 13782-01-9 $\text{K}_3\text{Co}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$ Yellow crystals	Cobalt potassium nitrate Pigment: Cobalt yellow; Aureolin; Fisher's salt	Oil-based glazes; colorant in glass; watercolor and tempera paints; pigments	TLV: 0.02 mg/m ³ (as TWA) (as Co), A3 (ACGIH 1997)
COPPER (Cu) 7440-50-8 Metal; Red powder, turns green on exposure to moist air. Cu/CuO fume 1317-38-0	Mineral: Chalcopyrite (primary ore); Native copper Cu fume: Copper fume CuO: Copper monoxide fume; Copper (III) oxide fume;	Metal alloys; solder; ammunition; construction; shipbuilding; roofing; plumbing pipes; water pipes; household fixtures; metal nails; electrical wiring; heat conductor; electromagnetic motors; electromagnets; generators, and transformers; electrical relays and switches; integrated circuits; vacuum tubes; cathode	OSHA PEL: TWA: 1.0 mg/m ³ . The PEL applies to other copper compounds (as Cu) except copper fume. Fume: TWA 0.1 mg/m ³

<p>COPPER (Cu) 7440-50-8 Metal; Red powder, turns green on exposure to moist air.</p> <p>Cu/CuO fume 1317-38-0</p>	<p>Mineral: Chalcopyrite (primary ore); Native copper</p> <p>Cu fume: Copper fume CuO: Copper monoxide fume; Copper (III) oxide fume; Cupric oxide fume; Black copper oxide fume; Copper oxide, Red</p> <p>Copper oxide, Black: Black copper oxide fume Copper oxide, Red: Cuprous oxide; Cuprite</p>	<p>Metal alloys; solder; ammunition; construction; shipbuilding; roofing; plumbing pipes; water pipes; household fixtures; metal nails; electrical wiring; heat conductor; electromagnetic motors; electromagnets; generators, and transformers; electrical relays and switches; integrated circuits; vacuum tubes; cathode ray tubes; extinguishing powder in Class D fire extinguishers; magnetrons in microwave ovens; cooking utensils; medical purposes; germicidal; musical instruments; jewelry; ornaments; sculpture; bronze and brass powders used for imitation gold; copper leaf; colorant in glass production; pigments; geological specimens</p>	<p>OSHA PEL: TWA: 1.0 mg/m³. The PEL applies to other copper compounds (as Cu) except copper fume. Fume: TWA 0.1 mg/m³</p> <p>Essential metal with potential for toxicity [6]. Inhalation of fume may cause metal fume fever.</p>
<p>Copper acetate 142-71-2 Cu(C₂H₃O₂)₂·H₂O Dark green crystalline powder</p>	<p>Cupric acetate; Crystals of Venus; Verdet; Verdiris</p>	<p>Fungicide; pesticide; textile dye; pigment for ceramics, inks and paints</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>
<p>Copper acetate, dibasic 52503-64-7 Cu(C₂H₃O₂)₂ · 2Cu (OH)₂ Blue-green crystals or powder</p>	<p>Basic copper acetate; Copper subacetate; Cupric acetate, basic Pigment: Blue Verdigris; Common Verdigris; French Verdigris; Green Verdigris; Van Eyck green; <i>vert de Grece</i></p>	<p>Pigment used in early oil paintings was fugitive and can turn dark brown; used on parchment to illuminate books between 15th and 19th century; fungicide; pesticide; textile dye; pigment for ceramics and paints</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>
<p>Copper acetoarsenite 12002-03-8 C₄H₆As₆Cu₄O₁₆ White solid tinted bright green</p>	<p>Copper acetate arsenite; Copper aceto-arsenite Cupric acetoarsenite; (Aceto) Trimetaarsenitodicopper; Trade names (insecticides): Ortho P-G Bait; Sowbug Cutworm Control; other Pigments: Emerald green; French green; Paris green; Schweinfurt green; Mitis green; C.I.Pigment Green 21; Imperial green; King's green; Meadow green; Mineral green; Moss green; Parrot green; other</p>	<p>Insecticide for agricultural, horticultural use; imitation bronze patina; antifouling agent in marine paints; pigments</p>	<p>OSHA PEL: [1910.1018] TWA 0.01 mg /m³ (as As) *Potential carcinogen [28]</p>
<p>Copper arsenate 10103-61-4 As₂Cu₃H₈O₁₂/Cu₃(AsO₄)₂ · 4H₂O Blue or bluish-green powder</p>	<p>Copper (II) orthoarsenate; Arsenic acid, copper salt</p>	<p>Insecticide; wood preservative</p>	<p>TLV: ppm; 0.2 mg/m³ (as As), ACGIH 1992-1993)</p>
<p>Copper (II) arsenite 10290-12-7 CuAsHO₃ Yellowish-green powder</p>	<p>Copper orthoarsenite; Acid copper arsenite; Cupric arsenite; Arsenious acid, copper (II) salt Trade names: Copper Orthoarsenite; Air-Flo Green Pigment: Scheele's green; Swedish green; Cupric green</p>	<p>Fungicide; insecticide; rodenticide; wood preservative; pigments</p>	<p>TLV: ppm; 0.01 mg/m³ (as As), A1 (ACGIH 1998)</p>
<p>Copper (II) carbonate 1184-64-1 CuCO₃ · Cu(OH)₂ Green crystals</p>	<p>Basic copper carbonate; Cupric carbonate Mineral and Pigment: Malachite; Mountain green Artificial: Green Verditer</p>	<p>Corrosion product of copper, copper alloys; fungicide; fireworks; pigments; occasionally found in tempera paints prior to and after 16th century; used in distemper and oil based paints in 19th century; geological specimens; gemstones</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>
<p>Copper (II) carbonate 1184-64-1 2CuCO₃ · Cu(OH)₂ Blue crystals</p>	<p>Basic copper carbonate; Cupric carbonate Mineral and Pigment: Azurite (Mountain blue) Pigments: Artificial pigment: Blue Verditer; Ashes blue; Blue bice (greenish-blue color); Bremen blue</p>	<p>Corrosion product of copper, copper alloys; fungicide; fireworks; pigments; geological specimens; gemstones</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>

<p>Copper chromated arsenate Formula varies Green tint</p>	<p>CCA; Chromated copper arsenate Trade name: Tanalith</p>	<p>Wood preservative for pressure treated wood (certain products canceled 2003)</p>	<p>OSHA PEL: TWA: 1.0 mg/m³; TLV: 0.05 mg/m³ (Cr VI compounds); TLV: 0.5 mg/m³ (Cr III compounds);</p> <p>OSHA PEL: [1910.1018] TWA 0.01 mg /m³ (as As)</p> <p>OSHA PEL: TWA: 1.0 mg/m³. The PEL applies to other copper compounds (as Cu) except copper fume. Fume: TWA 0.1 mg/m³</p>
<p>Copper naphthenate 1338-02-9 Green liquid with petroleum-like odor</p>	<p>Copper salt of naphthenic acid; Paint drier Trade names: Cuprinol; Cuprinol Green; Redycoat; Shakelast; Wittox-C</p>	<p>Used in solution with mineral spirits or oils; fungicide; insecticide; wood preservative; antifouling paints</p>	<p>OSHA PEL: TWA: 1.0 mg/m³ (as Cu)</p>
<p>Copper nitrate 3521-23-8 Ca(NO₃)₂ Green-blue deliquescent crystals</p>	<p>Cupric nitrate</p>	<p>Fungicide; wood preservative; mordant and oxidizing agent for textile dyeing; colorant for metals; pigment for ceramic, enamels, and glass</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>
<p>Copper sulfate (anhydrous) 7758-98-7 CuSO₄ White hygroscopic or pale green crystals Pentahydrate form is bright blue crystals</p>	<p>Cupric sulphate, Sulfuric acid, copper(2+) salt(11); Copper (II) sulfate; Blue vitriol; Bluestone Anhydrous Mineral: Chalcocyanite Pentahydrate Mineral: Chalcantinite</p>	<p>Analytical agent in certain chemical tests including Fehling's solution, Benedict's solution, and Biuret reagent; hardener for cattle hooves; used to grow crystal (laboratory); hair dyes; agent in certain fungicides, herbicides and pesticides; colorant for glass</p>	<p>OSHA PEL: TWA 1.0 mg/m³ as copper dusts and mists</p>
<p>HAFNIUM (POWDER) (Hf) 7440-58-6 Gray powder Metal is highly lustrous, ductile, grayish solid; Often associated with Uranium, Yttrium, and Zirconium in natural minerals</p>	<p>Celtium; Elemental hafnium; Hafnium metal Minerals: Found in Zircon, Cyrtolite, Alvite, Malacon</p>	<p>Neutron absorbing material in nuclear reactors; filament in light bulbs; cathode in x-ray tubes; oxygen and nitrogen scavenger; glass; geological specimens</p>	<p>OSHA PEL: TWA 0.5 mg/m³. The PEL applies to other hafnium compounds (as Hf).</p>
<p>IRON (OXIDE dust and fume) 1309-37-1 Fe₂O₃ Reddish-brown solid</p>	<p>Ferric oxide; Iron(III) oxide; Crocus powder Mineral: Hematite in many varieties (red or black); Magnetite; Kamacite and Taenite (iron-nickel meteorites) Pigments: Iron oxide red; Hematite; Red ochre; English red; Indian red (from India); Light Red; Pozzuoli red (volcanic origin from Pozzuoli near Naples); Venetian red</p>	<p>Construction; machinery; tools; weapons; corrosion product (rust); jeweler's rouge; magnets; colorant in glass production; pigments; geological specimens</p>	<p>OSHA PEL: TWA 10 mg/m³; 5 mg/m³ (resp); TLV: 1 mg/m³ (soluble salts)</p> <p>Fe metal is an essential metal with potential for toxicity [6].</p>
<p>Ferric ammonium sulfate 10045-89-3 FeNH₄(SO₄)₂·12H₂O Pale lilac crystals; effloresce in air Also light green crystalline solid</p>	<p>Ferric alum; Iron ammonium sulfate; Ammonium ferrous sulfate; Ammonium iron sulfate; Diammonium iron disulfate Trade Name: Mohr's Salt</p>	<p>Metallurgy; chemical analysis; medicine; toning solutions for black and white photography; mordant in textile dyeing</p>	<p>TLV: 1.0 mg/m³ TWA as soluble iron salt (as Fe) (ACGIH)</p>

Ferric arsenite 63989-69-5 $As_2Fe_2O_6 \cdot Fe_2O_3 \cdot 5H_2O$ Brown powder	Iron (iii)-o-arsenite, pentahydrate	Antidote for arsenical poisoning; co-precipitate of arsenic reduction/removal from water and mines	OSHA PEL: [1910.1018] TWA 0.01 mg/m ³ (as As) *Carcinogen [23]
LEAD (Pb) 7439-92-1 Bluish-white or silvery-grey solid in various forms. turns tarnished on exposure to air	Lead metal; Plumbum Minerals: Anglesite; Boleite; Boulangerite; Bournite; Bournonite; Cerussite; Curite; Descloizite; Finnemanite; Fiedlerite; Galena; Georgiadesite; Heliophyllite; Jamesonite; Kasolite; Linarite; Mimetite; Pentfieldite; Phoenicochroite; Phosgenite; Pyromorphite; Schultenite; Vanadinite; Wulfenite	Environmental excess exposure due to vehicle exhaust and industrial uses; metal alloys; solder; construction; brass pipe fittings; bearings; tools; metal chain ballast; gaskets gasoline additives; pesticides; lead labels on specimens; ear liners on taxidermy mounts; sculptures; older toys (paint and major component e.g. lead figurines); ceramic clay bodies and glazes; glass production; enamel in cloisonné materials; metal coatings; foil; lead-acid batteries; battery clamps; cables; radiation shields; ammunition; fireworks; counter-weights; sash weights; plastics; glass (including beads); came for stain glass panels; linotype printing blocks; lead inlay such as on Asian lacquer pieces; microchemical tests; Oddy test; mordant in textiles; weighted silks; salts used to speed curing time of drying oils; old house paint; paints; pigments; geological specimens	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ . The PEL applies to other Pb compounds. Major toxic metal [6]. *Human mutagen; birth defects; retardation; some compounds are probable carcinogens
Lead acetate 301-04-2 $C_4H_6O_4Pb$ Colorless crystals or white powder	Acetic acid lead salt; Lead (II) acetate; Lead diacetate; Lead dibasic acetate; Neutral lead acetate; Plumbous acetate, Salt of Saturn; Sugar of lead	Insecticides; hair dyes; sweetener for food and wine (imported); dyes; antifouling paints; manufacture of black colors for japanning	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead antimonite 13510-89-9 $Pb_2Sb_2O_7$ Lemon yellow with variants of greenish, pinkish orange, or reddish tinged powder	Antimonite of lead Pigment (synthetic): Naples yellow; Antimony yellow; Pigment yellow 41	Colorant for ceramic tiles; glass; pottery glazes; paints; pigments	OSHA PEL: TWA 0.05 mg/m ³ (as Pb) OSHA PEL: TWA 0.5 mg/m ³ (as Sb)
Lead arsenate 7784-40-9 $PbHAsO_4$ Odorless white heavy powder	Arsenic acid, lead salt; Acid lead arsenate; Dibasic lead arsenate; Plumbous arsenate; Lead hydrogen arsenate; Acid Orthoarsenate Trade name: Lead arsenate; Gypsine; Soprabel; NU Rexform; Security; Talbot Mineral: Schultenite	Hardener in lead-antimony alloys; cable sheathing; insecticide; taxidermy; pigment; geological specimen	TLV (as TWA) 0.15 mg/m ³ as $Pb^3(AsO_4)_2$ (ACGIH 1997)
Lead arsenite 10031-13-7 As_2O_4Pb White powder	Lead (II) arsenite; Lead metaarsenite; Arsenious acid lead (2) salt	Insecticide	TLV (as Pb): ppm; 0.05 mg/m ³ , A3, (ACGIH 1999). TLV (as As): ppm; 0.01 mg/m ³ , A1, (ACGIH 1999) *Carcinogen; Reproductive toxicity [23]
Lead carbonate 598-63-0 $PbCO_3$ Colorless to grayish-white crystals	Carbonic acid, lead(2+) salt; Lead(2+) carbonate Mineral: Cerussite Pigment: Basic carbonate of lead: White lead; Cremnitz white; Kremnitz white; Flake white	Synthetic mother of pearl; pigments; geological specimens	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)

Lead carbonate, basic 2PbCO ₃ ·Pb(OH) ₂ White amorphous powder	1319-46-6 Basic white lead; Lead subcarbonate; Hydrocerussite; Lead flake Mineral: Hydrocerussite Pigments: Lead white; cremnitz white; Krems white; Silver white; Dutch white lead; French white; Vienna white; Flemish white; London white; Roman white; Pigment white No. 1	Ceramic glazes; used in drying oils; primary white pigment for oil paint and ceramic glazes prior to 20 th century; found in egg tempera, glue tempera, gum tempera; exterior paints; interior paints until restricted in 1950's and prohibited since 1978	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead chromate (VI) PbCrO ₄ Yellow to orange-yellow crystalline powder	7758-97-6 Plumbous Chromate; Chromic Acid, Lead (II) Salt (11); Minerals: Crocoite, Phoenicochroite. Pigments: Chrome Yellow; Cologne yellow; King's yellow (also see Orpiment for same name but different compound); Leipzig yellow; Paris yellow; C.I. Pigment yellow 34' C.I. 77600. Note: Chrome green (mixed lead chromate and Prussian blue; also called Cinnabar green or Zinnober green). Pigment: Chrome red; Chinese red	Pyrotechnics; pigments; geological specimens Pigment	TLV: 0.05 mg/m ³ (as Pb); 0.012 mg/m ³ (as Cr); NIOSH REL: 0.001 012 mg/m ³ (as Cr VI) *Carcinogen [5]
Lead iodide PbI ₂ Bright yellow powder (from reaction of lead acetate and potassium iodide)	10101-63-0 Lead (II) iodide	Cloud seeding; photography; bronzing; gold pencils; ormolu; printing	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead molybdenum Pb (MoO ₄) Yellow, orange, brown, gray, whitish crystalline solid	Mineral: Wulfenite	Geological specimens	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead naphthenate C ₇ H ₁₂ O ₂ - xPb Yellow semi-transparent paste	61790-14-5 Naphthenic acid, lead salt; Cyclohexanecarboxylic acid, lead salt Trade name: Nuodex	Insecticide; wood preservative; drier in oil paints and varnishes to speed polymerization and oxidation processes	TLV not established; OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead nitrate Pb(NO₃)₂ White or colorless crystals	10099-74-8 Lead (II) nitrate; Lead dinitrate; Plumbous nitrate	Oxidizing agent; engraving and lithographic processes; photography; stain for mother-of-pearl; mordant in dyeing and printing calico	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)
Lead (II) oxide PbO Odorless grey to yellow-green to red-brown crystalline solid	1317-36-8 Lead monoxide; Plumbous oxide; Lead protoxide Mineral: Massicot Pigment: Massicot, yellow (made by gentle roasting of white lead); lead oxide yellow Litharge: Flake litharge, yellow-orange (formed from direct oxidation of molten metallic lead)	Batteries; lead crystal; flint glass; rubber vulcanizer; ceramics; dryer in paints and varnishes; important as intermediate step in preparation of red lead; pigments; geological specimens	TLV: ppm; 0.15 mg/m ³ as TWA (as Pb) (ACGIH 1992-1993)
Lead sulfide PbS Black to silvery powder or crystalline solid	1314-87-0 Galena; Leaded bisilicate ash; Plumbous sulfide Mineral: Galena (main source of lead)	Semi-conductors; infrared detectors as photon detectors; ceramic glazes; Medieval pottery; 17 th century slipware; geological specimens	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb)

Lead sulfide PbS Black to silvery powder or crystalline solid	1314-87-0	Galena; Leaded bisilicate ash; Plumbous sulfide Mineral: Galena (main source of lead)	Semi-conductors; infrared detectors as photon detectors; ceramic glazes; Medieval pottery; 17 th century slipware; geological specimens	OSHA PEL: 1910.1025 TWA 0.05 mg/m ³ (as Pb) *Suspect carcinogen [31]
Lead tetroxide Pb ₃ O ₄ Red or orange crystals or powder	1314-41-6	Triplumbic tetroxide; Lead orthoplumbate Mineral: Minium Pigments: C.I. Pigment Red 105; Lead oxide; Mineral red; Minium; Orange mineral; Paris red; Red lead; Saturn red	Older plumbing fixtures; batteries; amateur pyrotechnics; lead glass manufacture; enamels; ceramic glazes; flux in porcelain paints; rust proof paint; pigments; illuminated manuscripts	OSHA PEL: TWA 0.05 mg/m ³ (as Pb)
Tetraethyl lead Pb(C ₂ H ₅) ₄ Colorless liquid with characteristic odor	78-00-2		Motor fuel antiknock compound	OSHA PEL: TWA 0.075 mg/m ³ skin
Tetramethyl lead Pb(CH ₃) ₄ / C ₄ H ₁₂ Pb Colorless liquid with characteristic odor	75-74-1		Motor fuel antiknock compound	OSHA PEL: TWA 0.075 mg/m ³ skin
MAGNESIUM (Mg) Magnesium (Oxide fume) MgO Hygroscopic, fine, white powder	7439-95-4 1309-48-4	Magnesia; Magnesia fume; Calcined brucite; Calcined magnesia; Magnesium earth Minerals: Carnallite; Dolomite; Epsomite; Kieserite; Magnesite; Periclase Trade Names: Bookkeeper; Magcal, Maglite, Magox, Akro-Mag, Animag, Granmag, Magchem 100, Marmag	Light-weight metallic alloys; production of carbon dioxide; magnesia cement; medicinal purposes; fireworks; flashbulbs; optical mirrors; fillers in paper, ceramics, glass, and paint; ceramic glazes; glass production; non-alkalization agent for paper in conservation	OSHA PEL: TWA 15 mg/m ³ ; TLV: 10 mg/m ³ (fumes) Inhalation may cause metal fume fever. Mg metal is an essential metal with potential for toxicity [6]
Chrysotile Mg ₃ Si ₂ H ₄ O ₆ / Mg ₃ (Si ₂ O ₅)(OH) ₄ White, grey, green or yellowish curly fibrous solid	12001-29-5	Asbestos chrysotile; White asbestos; Serpentine chrysotile Mineral: Chrysotile (from serpentine rocks)	Building construction (in U.S. chrysotile accounts for 95% of asbestos use) e.g. corrugated cement roof sheets, flat sheets for ceilings, floors, walls; floor tiles; pipe insulation; joint compound; fireproof spun fabric; fire-protective cloth behind fuses; rope seals to boilers	TLV: 0.1 fibers/cc (as TWA) A1 (ACGIH 1998. For fibers longer than 5 um with an aspect ratio equal to or greater than: 3:1 as determined by the membrane filter method at 400-450X magnification (4-mm objective) phase contrast elimination)
Magnesium carbonate MgCO ₃ White powder Magnesium bicarbonate Mg(HCO ₃) ₂	546-93-0	Carbonic acid, magnesium salt Mineral: Magnesite Trade names: Gold Star; Hydromagnesite; Kimboshi; Magnesia	Production of carbon dioxide; absorbent for natural history specimens; paper washing; alkaline reserve for paper	OSHA PEL: TWA 15 mg/m ³ (total); TWA 5 mg/m ³ (resp) (as Mg)
Magnesium hydroxide	1309-42-8	Magnesium hydrate; Magnesia Magma	Manufacture of paper pulp; production of aqueous	OSHA PEL: TWA

Magnesium silicate hydrous 14807-96-6 $Mg_3(OH)_2Si_4O_{10}$ White powder	Hydrated magnesium silicate; Talc; Asbestine; French chalk; Steatite; Soapstone	Abrasives; fireproofing agent; fillers in paints, paper and crayons	TLV: 2 mg/m ³ (resp, no asbestos) (as Mg)
Magnesium sulfate 7487-88-9 $MgSO_4$ White crystals or powder	Magnesium sulphate Trade names: Epsom salts (as heptahydrate form) Minerals: Epsomite	Soil additive for plants; maintains magnesium balance in marine aquaria; medicinal uses including treatment of asthma, first aid for barium poisoning, anti-inflammatory, as a laxative; bath salts; flotation therapy; additive in some bottled water; coagulant in tofu production; desiccant in organic synthesis; lava lamp repairs; geological specimens	TLV not established
Methoxy magnesium methyl carbonate $3CH_3OMgOCO_2CH_3 \cdot CO_2$ Non-aqueous solution	Methyl magnesium carbonate; MMC; MMMC Trade name: Wei T'o™ #2	Paper deacidification	Not available
MANGANESE (Mn) 7439-96-5 Gray-white powder; lustrous, brittle, silvery solid.	Manganese metal: Colloidal manganese; Manganese-55 Minerals: Babingtonite; Bixbyite; Braunitz; Eosphorite; Ferberite; Franklinite; Hausmannite; Hauerite; Heubnerite; Johanssenite; Manganite; Manganosite; Phosphophyllite; Purpurite; Pyrolusite; Rhodochrosite; Rhodonite; Romanechite; Psilomelane; nodules on ocean floor Pigments: Manganese Blue (barium manganese-barium sulphate); Manganese Violet (manganese ammonium phosphate)	Metal alloy; welding alloys; deoxidizing agent; colorant in glass to produce pink tones; ceramic glazes	OSHA PEL*: 5.0 mg/m ³ CEILING; NIOSH REL: 1.0 mg/m ³ . Essential metal with potential for toxicity [6]. Mn dust is pyrophoric; ignites in chlorine
Manganese dioxide 1313-13-9 MnO_2 Black to brown powder	Manganese (IV) oxide; Manganese peroxide; Black oxide of manganese; C.I. 7728; Battery manganese Mineral: Pyrolusite Pigment: Manganese Black; Manganese brown (synthetic); Pigment black 14	Dry cell batteries (alkaline and zinc-carbon batteries); oxidizing agent; analytical catalyst; water treatments; glass production; colorant in mortar; drier for oil paints; pigments; geological specimens	TLV: 5.0 (dust) or 1.0 (fume) mg/m ³ ; RET as STEL: 3 mg/m ³ (fume) (as Mn) (ACGIH 1994-1995)
Manganese oxide 1317-35-7 Mn_3O_4 Brown to black crystalline powder	Trimanganese tetraoxide; Manganese tetroxide; Manganomanganic oxide Mineral: Hausmannite	Analytical catalyst in several chemical reactions; lithium batteries; geological specimens	TLV: 0.2 mg/m ³ (as Mn) (ACGIH 2001)
MERCURY (Hg) 7439-97-6 Odorless, heavy and mobile silvery liquid metal Hg ⁰ found in metallic or vapor form.	Quicksilver; Liquid silver; Colloidal mercury; Metallic mercury Mineral: Native metal; Cinnabar ore; Calomel; Montroydite	Mercury vapor is natural in atmosphere from degassing of earth's crust; extraction of gold; coal; manufacture of industrial chemicals; scientific instruments; thermometers; barometers; blood pressure monitors; light bulbs; mercury vapor lamps; some neon signs; contemporary compact fluorescent bulbs; electrical relay systems; silent light; switches; medicinal purposes (e.g. Mercurochrome, Calomel); antiseptics; laxatives; antidepressants; additive in inoculations; antisiphilitics; preservative in vaccines (Thimerosal); tattoo inks; early manufacture of felt, fur and wool; fungicides; herbicides; pesticides; photography; metal amalgams e.g gold gilding, silver; amalgam silvered mirrors; dental amalgam fillings; fixative in specimen preparation; blue neon gas; toys and toy paint; interior wall paint; pigments; geological specimens	OSHA PEL: 0.1 mg/m ³ CEILING; TLV: 0.05 mg/m ³ (skin; inorganic) Major toxic metal; vapor is most toxic form [6] *Central Nervous System damage *Probable developmental toxicant [5]

Mercuric arsenate HgHAsO ₄ Yellow powder	7784-37-4	C.I. 77762	Anti-fouling and waterproof paints	OSHA PEL: [1910.1018] TWA: 0.01 mg /m ³ (as As); OSHA PEL: 0.1 mg/m ³ (as Hg) CEILING; TLV: 0.05 mg/m ³ (skin; inorganic) (as Hg)
Mercuric chloride HgCl ₂ White crystals or powder	7487-94-7	Mercury dichloride; Mercury (II) chloride; Bichloride of mercury; Corrosive sublimate Trade names: Calochlor; Abavit B; Fungchex; Sulem; TL898; NCI-C60173	Antiseptic; disinfectant; tissue cell preservative; taxidermy; fungicide; herbicide; insecticide; pesticide; beetles, roaches, termites; on herbaria collections (still used in third world countries); photography; leather tanning; used to separate gold from lead; paint preservative	TLV: 0.025 mg/m ³ (skin, A4) (as Hg) (ACGIH 1999). *Most toxic Hg compound; ingestion of 0.5 grams can be fatal [5]
Mercuric nitrate Hg(NO ₃) ₂ White crystalline powder; colorless deliquescent crystals	10045-94-0	Mercury (II) nitrate; Mercury Dinitrate; Mercury nitrate monohydrate Trade names: Citrine ointment; Millon's Reagent	Analytical chemical; medicinal purposes; used in former carroting process in manufacture of felt, fur, wool until 1941 in U.S. (may still be present in objects made from recycled material); used in aqueous solutions for gilding	TLV: 0.025 mg/m ³ (skin) A4 (as Hg) (ACGIH 1999)
Mercuric oxide HgO Yellow or orange-yellow, or red heavy crystalline powder; yellow when finely powdered	21908-53-2	Mercury (II) oxide; Red mercuric oxide; Yellow mercuric oxide; mercury monoxide Trade names: Santar; Santar M; Natural Montroydite	Analytical reagent; chemical intermediate for mercury salts, organic mercury compounds, and chlorine monoxide; dry cell batteries; abrasives; glass modifier; preservative in cosmetics; antiseptic; fungicide; pigment modifier; pigment; formerly used in antifouling/marine paints	TLV: 0.025 mg/m ³ A4 (skin) (as Hg) (ACGIH 2000)
Mercuric sulfate HgSO ₄ Odorless, white crystalline powder	7783-35-9	Mercury(II) sulfate; Mercuric bisulfate	Gold and silver extraction; analytical chemical used to make other mercury compounds; medicinal purposes	TLV: ppm; 0.025 mg/m ³ (skin, A4) (as Hg) (ACGIH 1999)
Mercuric sulfide HgS Odorless red-orange or black powder	1344-48-5	Mercury sulfide; Mercury (II) sulfide; Red mercury sulfide; mercuric sulfide, black; mercuric sulfide, red; Ethiops mineral, black Pigment: Cinnabar (natural); Artificial cinnabar; English vermilion; Chinese vermilion; Chinese red; Minium (as used by early Greeks and Romans; modern term refers to artificial red lead); Orange vermilion; Scarlet vermilion; Vermilion; C.I. Pigment Red 106 Mineral: Cinnabar	Pigments; red ink as used by early (at least Hans) Chinese on cartouches, and stamp seals; geological specimens	OSHA PEL: 0.1 mg/m ³ CEILING; TLV: 0.05 mg/m ³ (skin; inorganic) (as Hg)
Mercurous chloride Hg ₂ Cl ₂ White crystalline powder	10112-91-1	Dimercy dichloride; Calomel; Mercury subchloride; mild mercury chloride Trade names: Cyclosan, M-C Turf fungicide	Medicinal purposes; teething powder; pesticide	TLV: 0.025 mg/m ³ (skin) A4 (as Hg) (ACGIH 1999)
Mercury bromide HgBr ₂ White crystalline powder	7789-47-1	Mercury (II) bromide; mercuric bromide; mercuric dibromide; mercury dibromide; Dibromomercury	Chemical reagent in Koenigs-Knorr reaction with carbohydrates; reagent in a chemical test for presence of arsenic	OSHA PEL: 0.1 mg/m ³ CEILING; TLV: 0.05 mg/m ³ (skin; inorganic) (as Hg)

<p>MOLYBDENUM (Mo) 7439-98-7 Dark gray or black powder with a metallic luster; silvery-white solid</p>	<p>Molybdenum metal Mineral: Molybdenite (MoS₂); Wulfenite Pigment: Molybdate orange</p>	<p>Found naturally in the soil; fertilizers; production of certain catalysts; high-temperature resistant steel alloys used in gas turbines and jet aircraft engines; propeller shafts; tools; boiler plates; rifle barrels; x-ray tubes; electrical contacts; filaments; glass to metal seals; lubricants, dyes; pigments; geological specimens</p>	<p>OSHA PEL: TWA 15 mg/m³ for <i>insoluble</i> Mo compounds. OSHA PEL: TWA 5 mg/m³ for <i>soluble</i> Mo compounds. Essential metal with potential for toxicity [6]</p>
<p>Molybdate orange (mixed compound of lead chromate, lead sulphate, lead molybdate)</p>		<p>Pigment</p>	<p>TLV: 0.05 mg/m³ (as Pb); 0.012 mg/m³ (as Cr); NIOSH REL: 0.001 mg/m³ (as Cr VI)</p>
<p>NICKEL (Ni) 7440-02-0 Silvery metallic solid in various forms; magnetic</p>	<p>Nickel metal: Elemental nickel; Nickel catalyst; White copper Mineral: Bunsenite; Garnierite; Niccolite (NiAs), also called Kupfernickel; Nickeline; Nitrobarite; Pentlandite; Pyrrhoite; Retgersite; Kamacite and Taenite (iron-nickel meteorites)</p>	<p>Metal alloys; stainless steels; magnets; electroplating; coins; chemical apparatus; analytical catalyst; cooking utensils; substitute for decorative silver; clothing fasteners; jewelry; green colorant in glass production; geological specimens</p>	<p>OSHA PEL: TWA 1.0 mg/m³. The PEL does not apply to Nickel carbonyl; NIOSH REL: 0.015 mg/m³ Major toxic metal [6] *Carcinogen Combustible Solid</p>
<p>OSMIUM (Os) 7440-04-2 Bluish-white solid</p>	<p>Mineral: Osmiridium; Iridosmine; trace element in all platinum ores</p>	<p>Manufacture of platinum alloys; analytical catalyst; electric light filaments. As an alloy with iridium: fountain pen points; surgical needles; phonograph needles; compass points; instrument pivots</p>	<p>Not available</p>
<p>Osmium tetroxide 20816-12-0 OsO₄ Colorless, crystalline solid or pale-yellow mass with an unpleasant, acrid, chlorine-like odor; turns to liquid above 105°F</p>	<p>Osmium (IV) oxide; Osmic acid anhydride; Osmium oxide; Tetraoxosmium Trade name: Milas' Reagent</p>	<p>Platinum group alloy; oxidizing agent; staining agent in Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM); staining agent for fatty tissue; intermediate in osmium ore refining; surgical implants such as pacemaker and replacement pulmonary valves; filament in Oslamp; forensic residue on archival material (osmium/ruthenium tetroxide); fingerprint detection</p>	<p>OSHA PEL: TWA 0.002 mg/m³ *Extremely toxic</p>
<p>PLATINUM (Pt) 7440-06-4 Silvery, whitish-gray, malleable, ductile metal. * Platinum group metals include ruthenium, rhodium, palladium, osmium, and iridium [6]</p>	<p>Platinum black; Platinum metal; Platinum sponge</p>	<p>Laboratory equipment; electrical contacts; catalytic converter; catalyst in fuel cells; bullion; electrolysis; photography; watch-making; jewelry; medical purposes; chemotherapeutic drugs; dentistry; surgical instruments; resistance thermometers; pen points; silvery color leaf; metal inlay in Egyptian boxes; used as simulated silver for decorative purposes</p>	<p>OSHA PEL: TWA 0.002 mg/m³; TLV 0.002 mg/m³ (soluble salts); TLV: 1.0 mg/m³ (metal)</p>
<p>RHODIUM (Rh) 7440-16-6 Metal: white with bluish-grey luster; hard, ductile. Powder: grey to black</p>	<p>Rhodium metal: Elemental rhodium Minerals: Rhodite; Sperryllite; Iridosmine; all Platinum ores</p>	<p>Alloying agent; electrodes for aircraft spark plugs; lab crucibles; optical instruments; coating on sterling silver; catalyst in catalytic converter systems; filter in</p>	<p>OSHA PEL: TWA 0.1 mg/m³ for <i>insoluble</i> Rh compounds. OSHA</p>

		mammography; pen surfaces; target element in some hand-held XRF instruments; high-reflectivity mirror surfaces on searchlights, optical instruments and cinema projectors; jewelry	PEL: TWA 0.001 mg/m ³ for <i>soluble</i> Rh compounds
SELENIUM (Se) 7782-49-2 Odorless solid in various forms. dark red-brown to bluish-black amorphous solid or red transparent crystals or metallic grey to black crystals *Metalloid; semi-metal	Elemental selenium, Selenium alloy; occurs as an impurity in most sulfide ores Mineral: Selenolite	Metal alloys; replacement (with bismuth) in brasses to replace lead rubber compounds; electronics; television screens; photocopiers; photocells; light meters; cameras; toners in photography; industrial radiography; solar cells; medical purposes; xero-radiography; red and pink colorant for ceramic glazes and glass; pigment manufacture	OSHA PEL: TWA 0.2 mg/m ³ . The PEL applies to other selenium compounds (as Se) except Selenium hexafluoride. Essential metal with potential for toxicity [6] *Mutagen [5]
Hydrogen selenide 7783-07-5 H ₂ Se Colorless compressed liquefied gas with characteristic odor	Selenium hydride; Dihydrogen monoselenide Trade name: Selane	Production of semi-conductors; synthesis of Se compounds	OSHA PEL: C: 20 ppm, 50 ppm, 10-minute maximum peak
SILVER (Ag) 7440-22-4 White metal, turns dark on exposure to ozone, hydrogen sulfide or sulfur	Argentum Pigment/gilding: Silver leaf; Silver powder, C.I. 77820	Metal alloys; amalgams; mirrors; electrical contacts; medical purposes; photographic plates; jewelry; coins; eating utensils; food and drink containers; silver foil; gilding; paint; pigment; geological specimens	OSHA PEL: TWA 0.01 mg/m ³ Minor toxic metal [6]. Can cause permanent blue-black stain on skin [5]
Silver nitrate 7761-88-8 AgNO ₃ Odorless, colorless transparent or white crystals	Nitric acid, silver (I) salt; Silver (I) nitrate; Silver mononitrate; Lunar caustic; Lapis infernalis	Organic synthesis; reagent in chemical spot test for chlorides; silver staining for proteins and nucleic acids; stain in SEM; photography; high refractive index glass for camera lenses; antiseptic; cauterizing agent; treatment of oral ulcers; silver mirrors; silver plating; hair dyeing; indelible inks; colorant for glass and porcelain	OSHA PEL: TWA 0.01 mg/m ³
TANTALUM (Ta) 7440-25-7 Steel-blue to gray solid or black, odorless powder	Tantalum metal; Tantalum-181; Tantalum oxide; Tantalum pentoxide; Tantalum acid anhydride Minerals: Found with Niobium in Columbite, Tantalite, Microlite, others	Alloys especially for carbide tools and jet engines; chemical process equipment; nuclear reactors; missile parts; electronic capacitors and resistors; pen nibs; surgical instruments; surgical implants; sutures and pins (bones); glass for telescopes and camera lenses; fine wire; filament	OSHA PEL: TWA 5.0 mg/m ³ Powder ignites SPONTANEOUSLY in air
TELLURIUM (Te) 13494-80-9 Dark gray to brown amorphous powder, with metal characteristics or silvery-white, lustrous crystalline solid. *Metalloid; semi-metal Part of sulfur and selenium family [6]	Aurum paradoxum; Metallum problematicum Minerals: Avicennite; Paratellurite; occurs as Telluride in gold, silver, copper, lead, and nickel ores	Produced as a by-product of metal refineries; used in refining of copper; manufacture of rubber; vapor is used in "daylight" lamps; a catalyst in certain metal alloys; used as a semi-conductor; production of solar cells; infrared detectors; thermoelectric generators; food packaging found in condiments, dairy products, nuts, fish; some plants such as garlic; colorant in	OSHA PEL: TWA 0.1 mg/m ³ . The PEL applies to other Te compounds except Tellurium hexafluoride and Bismuth telluride

			ceramic glazes and glass	Minor toxic metal [6]
THALLIUM (Tl) 7440-28-0 Bluish-white, very soft metal. turns grey on exposure to air	Ramor; Thallium (metal) Minerals: Carlinite; Crookesite; Hutchinsonite; Lorandite; Pierrotite; Routhierite		A by-product of refining cadmium, iron, zinc; catalyst in certain alloys and chemicals; nuclear medicine; optical lenses; glass windows; jewelry; infrared detectors; relays; switches; production of photo cells; low-temperature thermometers; semiconductors; scintillation counters; green pyrotechnics dyes; rat poison; ant killer; insecticides; production of artificial diamonds; pigments	OSHA PEL: TWA 0.1 mg/m ³ skin Minor toxic metal; some compounds are highly toxic [6] *Possible toxicity to human reproduction or development
Thallium sulfate 7446-18-6 O ₄ STl ₂ White powder tinted green	Trade Name: Ratox		Rodenticide, ants	TLV (as Tl): 0.1 mg/m ³ (as TWA) (skin) (ACGIH 1999)
TIN (Sn) 7440-31-5 Gray to almost silver-white, ductile, malleable, lustrous solid	Bright tin; Metallic tin; Tin flake; Tin metal; Tin plate; Tin powder; Silver mat powder Mineral: Cassiterite Trade names: C.I. Metal 5; Tin paste 62-1177; Wang		Manufacture of tin-plate; roof construction; solder; alloy in bronze and brass; pewter; decorative items; toys; plating for iron toys; glass production; medical purposes; food packaging; bactericides; fungicides; slimicides; stabilizers in plastics; textile mordents; gilding as tin leaf	OSHA PEL:TWA 2.0 mg/m ³ . Note: The PEL applies to other <i>inorganic</i> Sn except tin oxides. OSHA PEL: TWA 0.1 mg/m ³ for <i>organic</i> Sn compounds Minor toxic metal; some organic compounds are highly toxic [6]
Stannic oxide 18282-10-5 SnO ₂ White or slightly gray powder	Tin (IV) oxide; Stannic anhydride; Tin dioxide; Flowers of tin; Polishing powder; Putty powder; Tin ash Mineral: Cassiterite		Polishing abrasive	OSHA PEL:TWA 2.0 mg/m ³ (as Sn)
Stannic sulfide 1315-01-1 SnS ₂ Bronze yellow scaly crystalline powder	Tin IV sulfide; Tin disulfide; Artificial tin; Mosaic gold (also Purpurino); Bronze powder Trade name: Suvarnavanga (Indian Ayurvedic medicine)		Previous medical treatment for nervousness; pigment in bronzing and gilding	OSHA PEL: TWA 0.1 mg/m ³ for <i>organic</i> Sn compounds
TITANIUM (dioxide) 13463-67-7 TiO ₂ Colorless to white crystalline powder; dense white opaque powder	Titanium oxide; Titanium peroxide; Titania; Titanic anhydride; Titanic acid anhydride Minerals: Anatase; Brookite; Ilmenite (menachanite); Rutile Pigment: Titanium white; Pigment white 6 Trade names: Titanox (for pigment); C.I. 77891		Whitener in cosmetics, food, paper, plastics, toothpastes, gessoes; cement; textiles; leather ink; ceramic glazes; pigment; geological specimens; gemstones; imitation diamonds in paste jewelry	OSHA PEL: TWA 15 mg/m ³ Ti metal is a Minor toxic metal [6] *Potential Carcinogen
URANIUM (U) 7440-61-1 Silver-white, malleable, ductile, lustrous solid; weakly radioactive	Uranium I Minerals: Autunite; Bequerelite; Betafite; Carnotite; Curite; Descloizite; Kasolite; Pitchblende; Samarskite; Thorianite; Torbernite; Uraninite; Uranite Often associated with Hafnium and Yttrium Pigment: Kawai's yellow		Uranium: Fuel in nuclear reactors; nuclear weapons; armor plating; stains in TEM; radiometric dating of earth; radioactive specimens; vertebrate fossils; x-ray targets; toners in photography; lamp filaments; eyeglass lenses; dentures; smoke detectors cloisonné jewelry; colorant in uranium glass (Vaseline glass), ceramic glaze (Fiesta ware); textile mordents; stains	OSHA PEL: TWA 0.25 mg/m ³ (insoluble compounds); 0.05 mg/m ³ (soluble compounds) Minor toxic metal [6].

<p>URANIUM (U) 7440-61-1 Silver-white, malleable, ductile, lustrous solid; weakly radioactive</p> <p>Radon is derived from the radioactive decay of uranium to radium (226) then to radon gas</p> <p>Radium 7440-14-4 Ra</p> <p>Radon gas 10043-92-2 Rn</p>	<p>Uranium I</p> <p>Minerals: Autunite; Bequerelite; Betafite; Carnotite; Curite; Descloizite; Kasolite; Pitchblende; Samarskite; Thorianite; Torbernite; Uraninite; Uranite Often associated with Hafnium and Yttrium</p> <p>Pigment: Kawai's yellow</p>	<p>Uranium: Fuel in nuclear reactors; nuclear weapons; armor plating; stains in TEM; radiometric dating of earth; radioactive specimens; vertebrate fossils; x-ray targets; toners in photography; lamp filaments; eyeglass lenses; dentures; smoke detectors cloisonné jewelry; colorant in uranium glass (Vaseline glass), ceramic glaze (Fiesta ware); textile mordents; stains and dyes for leather and wood; pigments in paints.</p> <p>Depleted uranium: ammunition; shielding material; inertial guidance devices; gyroscopic compasses.</p> <p>Radium 226: glow-in-the-dark, luminous objects may still be radioactive even if no longer fluoresce: paints, clock and watch hands, compasses, doorknobs, altimeter, instrument panels, light switches, religious statuary, chamber pot lids; specific spa waters; bottles of health medicines or health cures with RAD or RADI in title [32, 34] .</p> <p>Radon gas: emitted from fossil and rock specimens; house foundations (e.g. basements) [32]; cancer treatment</p>	<p>OSHA PEL: TWA 0.25 mg/m³ (insoluble compounds); 0.05 mg/m³ (soluble compounds)</p> <p>Minor toxic metal [6].</p> <p>*Probable carcinogen</p> <p>Uranium is considered mildly radioactive; Radium is considered extremely radioactive.</p> <p>Rn: TLV not established</p>
<p>VANADIUM (V) 7440-62-2 Metallic gray rod /chunks</p> <p>Vanadium dust 1314-62-1 V₂O₅ Yellow-orange powder or dark-grey, odorless flakes dispersed in air.</p> <p>Vanadium fume V₂O₅ Finely divided particulate dispersed in air</p>	<p>Mineral: Anadinite; Carnotite; Karelitanite; Shcherbinaite; Vanadinite; Volborthite</p> <p>Divanadium pentoxide dust or fume; Vanadic anhydride dust or fume; Vanadium oxide dust or fume; Vanadium pentaoxide dust or fume; Vanadium(V)oxide</p>	<p>Vanadium is a by-product of petroleum refining; nuclear applications; hardener for steel; surgical instruments; tools; axles; crankshafts; gears; photography; insecticides; target material for x-rays; UV absorbers; increases rust-wear resistance in steel; lacrosse shafts; food additive e.g. milk, seafood, cereals, vegetables; medical implants; simulated alexandrite jewelry; yellow and red colorants in ceramic glazes and glass; colorant for red phosphor in color television tubes; textile mordant</p> <p>Vanadium pentoxide is used as a catalyst in various chemicals including sulfuric acid</p>	<p>OSHA PEL: 0.5 mg V₂O₅/m³ (resp dust) CEILING</p> <p>OSHA PEL: C: 0.1 mg V₂O₅/m³ fume</p> <p>Minor toxic metal [6].</p>
<p>YTTRIUM (Y) 7440-65-5 Dark-grey to black, odorless solid</p>	<p>Yttrium metal</p> <p>Minerals: Fergusonite; Gadolinite; Yttrialite; Xenotime; found in almost all rare earth minerals. Often associated with hafnium, uranium and zirconium</p>	<p>Component in cathode ray tube display of television or LED; production of electrodes, electrolytes, electronic filters, lasers, superconductors; medical applications; analytical catalyst; gas mantle for propane lanterns; production of magnets; geological specimens</p>	<p>OSHA PEL: TWA 1.0 mg/m³. The PEL applies to other Y compounds.</p>
<p>ZINC (Zn) as powder or dust 7440-66-6 Odorless grey to blue powder</p>	<p>Zinc metal, fume or dust; Zinc powder; Blue powder</p> <p>Trade name: Merrillite; Ascarco L 15; ECKA 4; Rheinzink</p> <p>Minerals: Hemimorphite; Smithonite – both previously referred to as Calamine</p>	<p>Nuclear technology; coating on high temperature alloys; metal alloys; plating; solder; batteries; contemporary pipe organs; microwave band pass filters in communication networks; lasers; production of artificial diamonds; medicinal purposes; skin rash treatments (e.g. Calamine); deodorant; anti-corrosion product; glass production; pesticide; wood preservative; plastic lubricant; reagent in chemical spot tests (e.g. arsenic spot test); pigments including zinc sulfide in luminescent pigments; geological specimens</p>	<p>TLV: 5.0 mg/m³ (fumes)</p> <p>Essential metal with potential for toxicity [6]</p> <p>*Metal fume fever is a concern.</p>
<p>Zinc arsenate 13464-44-3</p>	<p>Arsenic acid, zinc salt; Zinc orthoarsenate</p>	<p>Herbicide; insecticide; rodenticide</p>	<p>OSHA PEL:</p>

Zinc chromate ZnCrO ₄ Yellow crystalline powder. (a Cr (VI) compound [5])	13530-65-9	Chromium zinc oxide; Zinc Chromate (VI) hydroxide; Zinc tetraoxychromate; Chromic acid, zinc salt (11); zinc chromate is also used to refer to a wide range of commercial zinc and zinc potassium chromates Pigments: Zinc yellow; Pigment Yellow 36; Buttercup Yellow	Pigments.	TLV: 0.01 mg/m ³ (as Cr)
Zinc hexafluorosilicate Zn(SiF ₆) White crystalline solid	16871-71-9	Zinc fluorosilicate; Zinc silicofluoride Trade Names: Berlou; Arko Moth Proof	Insecticide; mothproof; hardener for concrete; fixative for acid dyes	TLV: 2.5 mg/m ³ (as F)
Zinc oxide ZnO Odorless white powder or crystals	1314-13-2	Zinc white; Zinc monoxide; Zinc peroxide Pigments: C.I. Pigment white 4; Chinese white; Zinc white	Rubber industry; semi-conductors; light emitting diodes; sunburn and windburn skin protection ointment; diaper rash ointment; Calamine lotion; throat lozenges; cosmetics; dentistry; food additive; pharmaceuticals; UV absorber; ceramic glazes; printing inks; colorant for glass; pigments	OSHA PEL: TWA 5.0 mg/m ³ (fume); TWA 15 mg/m ³ (total dust); TWA 5 mg/m ³ (resp dust) (as Zn) *Metal fume fever is a concern
Zinc phosphide P ₂ Zn ₃ Black to gray powder or paste	1314-84-7	Trizinc diphosphide Trade Name: Arrex; Phosvin; Ridall-Zinc; Ridall-Z; Zinc-Tox	Pesticide; rodenticide	TLV not established
Zinc sulfate heptahydrate ZnSO ₄ • 7H ₂ O Granules or crystalline powder	7446-20-0	Mineral: Goslarite; White vitriol	Medicinal purposes; astringent; emetic; coagulation baths for rayon; electrolytes; skin and leather preservative; textile mordant	TLV not established
Zirconium (Zr) Lustrous grey-white metal	7440-67-7	Zirconium element; Zirconium metal (liquid, suspension); Zirconium suspended in flammable liquid Mineral: Baddeleyite; Eudialyte; Malacon; Zircon (Zr silicate); Zirkelite; some rare earth minerals	Nuclear reactors; weapons; space vehicles; explosive primers; vacuum tube getters; surgical appliances; filaments; light bulbs; abrasives; grinding wheels; sandpaper; modern pigments; geological specimens; gem stones	OSHA PEL: TWA 5.0 mg/m ³ (as Zr compounds)
Zirconium oxide ZrO ₂ White powder	1314-23-4	Zirconia; Zirconium dioxide; Zirconium (IV) oxide; Zirconic anhydride Trade names: C.I. Pigment white 12; Zirconium white; Zirox 180 Mineral: Baddeleyite	Thermal barrier coating in jet turbine and diesel engines; refractory material; insulation; fiber insulation; oxygen sensors; fuel cell membranes; electroceramics; limelight; casing in some mobile devices; radio transparency; abrasives; enamels; ceramic glazes; pigments; simulated diamonds; geological specimens; gemstones	OSHA PEL: TWA 5.0 mg/m ³ (as Zr)