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The SPEX Speaker

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SOCIETY DISCOVERS SIGNAL-TO-NOISE

Whether a research scientist or engineer, you're sure to be on familiar terms with signal-to-noise. True, you may refer to it differently but its import and impact remain remarkably similar from one discipline to another. A preparative chemist speaks of the "yield" of a particular synthesis. To the physicist studying low-light phenomena the "dark count" of a photomultiplier is what limits detectivity. An electrical engineer is constantly concerned with the "Q" of the circuit. The power-plant engineer who must thresh out the last bit of "efficiency" in processing latent into transmittable energy knows "friction" as noise. To the analytical chemist the "blank level" of reagents imposes the limit of detection. And for a spectrochemist—a sub-species of analytical chemist—signal-to-noise translates into "line-to-background."

Powerful and ubiquitous to the technologist, the concept of signal-to-noise has only recently spilled over into other fields. From sociologists, economists, ecologists, politicians and laymen we now regularly hear of the "benefit-to-risk" or "benefit-to-cost" ratio of a particular proposal. In facing the complex issues of our society they studiously weigh numerator against denominator and respect the quotient. An Alaskan pipeline must not only transport oil to its destination; it must earn social acceptance through careful design, engineering and maintenance plans.

The Alaskan pipeline underscores a condition common to most major issues facing government today: sensible decisions require comprehensive technical expertise. Moreover, the factors involved may be so complex, spanning so many diverse specializations, that "correct" decisions become feasible only through intermeshed efforts of numerous technologists, each expert in a discreet and often esoteric field. It took highly specialized scientists to recognize, when the SST was being developed, that its probable tearing of the ozone umbrella in the upper atmosphere was a compelling counter consideration. It also took a large effort by the Federation of American Scientists to sufficiently publicize the risk factors and attain a meaningful level of political support for their position. Not so luckily, other projects have proceeded to the point of no-return before their "noise" intensity registered. Thus, is the inglorious Four Corners power plant noteworthy. A huge coal-burning facility was constructed where Arizona, New Mexico, Colorado and Utah converge. Environmentalists' objections were placated by locating the plant far from large cities, outfitting it with precipitators purported to remove most of the flyash, and with skyscrapered stacks. The measures proved grievously inadequate as, daily, tons of residual flyash and voluminous sulfurous fumes foul the atmosphere of towns a hundred miles away.

Should location and design of a Four Corners plant be arbitrated by lawyers or should the pull of political expediency be balanced by the most educated, impartial, scientific opinions available? Will present procedures for restoring strip-mined countryside be adequate over the long term? Should a green light continue to be given to construction of fast-breeder atomic reactors? How safe is the gamble on fusion reactor research? Is unleaded gasoline needed to help clear up automotive pollution? Do the dangers of spills outweigh the potential advantages of drilling for oil off the Atlantic coast? What radioactivity levels are acceptable? What concentration of vinyl chloride, recently linked to 21 cases of a rare liver cancer, should be permitted in plants?

From such questions a new discipline has emerged: public interest science. Arriving a bit belatedly on the technology scene, public interest science is immediately confronted with challenges so involved that there is not ready agreement, even among scientists, on optimum solutions. In a recent talk before the Edison Institute, H. Guyford Stever, director of the National Science Foundation, discussed one of these major problems: power generation. Ever since the electric generator was invented, individual power plants have tended to grow larger and still larger. The larger the plant, the more efficient its operation, the cheaper it could transmit its power—has been a long-accepted aphorism. Now Stever questions that "conclusion" on technical grounds. During the next 10-20 years he foresees a transition period in which no one source of power should dominate. In one area of the country he feels it may be best to run some autos on methane generated from organic products, some on hydrogen electrolyzed from water, some on batteries, huge flywheels, or gasoline. Likewise, a scattering of small power plants operating on different fuels may be more economical, better related to population densities and politically advantageous over a single large energy site. We are already aware of the need for nuclear fuels but, where available, water or geothermal power might well be preferable. Pumped storage or windmills might be ideal for peak-period supplementation to cities. And homes in suitable locales might be partially or completely heated or cooled by solar energy. Stever's thought-provoking conclusion is that it is "unwise at the moment to place our bets too heavily in favor of any one source—as we have in the past." Does such a sensible approach—or preposterous idea—stand a chance of implementation against the pressure of an AEC and its entourage of industrial giants who are constantly lobbying for more and larger atomic plants? An 8-page, full-color advertisement by one of the major producers of nuclear reactors, calling for stepped-up production of conventional and breeder reactor facilities, appears in a recent issue of a national magazine. Would disinterested technologists arrive at the same conclusion? Where can we hear their voices equally loudly?

A look at several major global problems has motivated us to bring to your attention the need, as we see it, for a stronger science voice in effecting solutions that will optimize benefit to cost, the denominator including ecological and sociological risks.

DWINDLING NATURAL RESOURCES

The urgency of recycling our natural resources should hardly be a controversial issue. But recycling is oftimes a catchword more disposed to continuing debate than to determined action. From the comfort of easy chairs there is general agreement that returnable bottles consume less glass, energy and disposal space than throwaways. Yet only Oregon and Vermont have adopted laws banning soft drinks and beer in non-return containers. In two years since enactment of the Oregon law, litter on the streets and highways has decreased by as much as 84%, waste disposal is a dramatically reduced burden and Oregon has saved 3000 BTUs of energy, enough to heat 24,700 homes. Extrapolating countrywide, 5% of our homes could be heated with energy presently spent producing throwaway containers.

Yes, there have been concurrent hardships, for example, one canning plant employing 70 has closed. But many supermarkets have had to add employees to handle returns. Even if manufacturers of glass, steel and containers suffer reduced growth, however, should not the desirability quotient be calculated by disinterested persons with at least a smattering of knowledge and concern for depleting mineral and disposal resources? Is it time for a national law against "no returns"? If so, is the picture being clearly painted for our congressmen? Why then do Mark Hatfield's S 2062 and Don Edwards' H.R. 9782 languish in Congress? Or, considering mainly employment dislocations, will it be preferable to produce the "convenience packages" then invest the manpower to diligently collect, separate and recycle them? If that is preferable then it, too, will take nationwide action to achieve.

And then, who can be expected to take the initiative in considering the fate of less bountiful metals that are relentlessly being moved from accessible mountains of ore to almost irrecoverable mountains of waste? Tungsten in incandescent lamps; manganese, mercury, cadmium and nickel in batteries; silver in photographic film; tin, gold, and gallium in electronic appliances; rare earths in lantern mantles and cigarette lighters; molybdenum in grease. Shouldn't there be at least a start at separating and reclaiming these metals before they are haphazardly and irretrievably dumped? Helium, in a class by itself, floats to the atmospheric surface never to return. Everywhere on earth but in America it is sold only for closed-cycle applications. Will we join in this mature conclusion before it becomes the first extinct element?

ENERGY

We quote from the July 6, 1974 editorial of the NEW YORK TIMES a particularly logical and succinct statement.

> One major difficulty is that the nation suffers from want of knowledge concerning the ways to extract energy from the earth at the lowest possible cost to the environment—an ignorance that the Government shares. This ignorance explains, at least in part, the Federal Government's dismal failure to make decisions and to fix priorities until the very moment that a jolting energy shortage appears out of the blue. In the paralyzing apathy between such crises, bills to authorize energy research and set up responsible agencies to deal with the problem move but glacially through Congress.
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> The prevailing uncertainties reflect no dearth of printed information, public oratory or vigorous contention. But a vast amount of it is self-interestedly biased in favor of one energy source to the detriment of others, or passionately against one source for the harm it will do in a given area and indifferent to the damage that other forms of energy might do elsewhere.
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> The net result is that every concerned person knows that the strip-mining of coal without full reclamation requirements can be devastating to the land. He knows that offshore oil can ruin beaches, that nuclear power produces lethal wastes and can be unsafe, that the extraction of shale oil can mar the land and degrade a river. He knows the harm that can be done by an oil pipeline in delicate terrain, the danger of supertankers and the desirability of locating an oil refinery anywhere but on the site chosen. Even the excellent Ford Foundation pamphlets on energy lean, as they must, to the negative—for example, the plea to put off decisions on offshore oil and superports rather than make them in "considerable ignorance and uncertainty."
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> Sooner or later the public has a right to expect Government to make such decisions on the basis of knowledge and at least reasonable assurance. The country should be told what the best trade-offs might be—if indeed any are found necessary in the light of what energy might be saved by rigorous conservation.
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> But if the public is to have full confidence in decisions of such far-reaching consequence, they must be based on the findings of experts as wise and objective as the nation can call on. It is time that the haphazard policies produced by catering first to one self-interest group and then another be replaced by the recommendations of a blue-ribbon, nonpartisan commission. Taken from the ranks of the country's leading scientists, technicians, economists, ecologists and—yes—philosophers, such a body would have a chance of reaching not a perfect solution, but so tolerable a reconciliation of conflicting needs that most Americans would probably be willing to make the required concessions.

We feel a particularly urgent plea should be added here for attention to the safety of nuclear reactors. If only 100 grams of plutonium-239, "lost" or stolen from a fast breeder plant, could fuel an almost unimaginably devastating bomb, should the go-no go decision to build such plants be left to the Atomic Energy Commission and the reactor industry, both of which are stanchly committed to present nuclear technology by powerful financial ties? If the escape and dispersion into the atomsphere of a few grams of plutonium-239 from a breeder fission reactor could wipe out every living creature in the world, is any need sufficient for the risk?

Yet several fast breeder plants are already producing large-scale electrical power in France, England and Russia. In the United States, an experimental breeder is currently feeding 18.5 MW into Idaho power lines. There, a closed-cycle operation was designed to contain the dangerous and incredibly toxic Pu-239, with its bomb potential and 24,000-year radioactive half-life.

Are there other, possibly preferable, alternatives? It is some comfort that the American Physical Society has established an Energy Planning Committee which is sponsoring a study this summer of the technical aspects of reactor safety. At the same time, this group is taking a needed look at means for improving the efficiency of energy utilization at the point of use. We mean to watch closely for their reports and hope some light will be shed on any alternatives to the fast breeder, such as the fusion reactor. The disappointing pace of fusion development has been an indisputable argument against it, but if the hydrogen-bomb mustang can be domesticated into a clean, efficient workhorse, the APS reports might highlight that possibility along with any other that promises to avoid the apocalypse of a breeder-reactor accident. It will be up to each of us, then, to help alert the public and produce the political pressures required to force a constructive government response.

AUTOMOTIVE POLLUTION

Accepted with about the same quantum of qualms as preserving mineral resources is the notion of stopping automobile pollution. Legislated into corrective action several years back, the industry chose its traditional bolt-on approach. Quickly locking themselves into the catalytic converter, U.S. manufacturers resisted basic design changes, leading us instead through the chain of requiring lead-free gasoline, lower octane ratings and reduction of engine compression ratios. The hitch in this hastily chosen route is fuel efficiency. Low-compression cars get fewer miles per gallon, made fewer yet by the converters, resulting in further aggravating the already tender world-wide oil wounds.

Meanwhile, Japan's 1973 Honda met the clean-air standards which American factories claim are impossible to achieve by 1975 or 1976 or is it 1977 or later by now? By means of a comparatively simple modification of the traditional 4-stroke piston, their little car boasts a stratified charge, high-compression engine running on leaded or unleaded gasoline, with an efficiency that it is estimated could save motorists $6.5-billion annually. Could an impartial but organized lobby in Washington have blazed some such anti-pollution trail for us?

CONCLUSIONS?

One compellingly clear lesson for the part-time motorist, full-time U.S. citizen is: optimum solutions cannot be expected from vested-interest groups. From sewage sludge recycling as fertilizer with its obvious advantages and hidden dangers of heavy-metal build-up; to the wonders and horrors of DDT; to the cleaning miracles and clogged waterways attributable to synthetic detergents; to the grandeurs and limitations of damming the Colorado; to the temptations and shame of scarring our land with strip-mines or oil-shale tailings; to pleasing our palates with steaks costing 1600 pounds of grain per person fed annually when each 400 pounds would amply feed a person a year where starvation now spreads; and finally or firstly to the overriding world-wide dilemmas of economic and population growth. Can we, the science-trained individuals, do more to aid the process of sound, constructive reasoning toward attaining the highest S/N?

By 1960 Bertrand Russell had warned:

> . . . what ought to be known widely throughout the general public will not be known unless great efforts are made by disinterested persons to see that the information reaches the minds and hearts of vast numbers of people. I do not think this work can be successfully accomplished except with the help of men of science.
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> . . . I think men of science should realize that unless something rather drastic is done under the leadership or through the inspiration of some part of the scientific world, the human race, like the Gadarene swine, will rush down a steep place to destruction in blind ignorance of the fate that scientific skill has prepared for it.

Since then our organizations of scientific professionals have come a long way to make themselves heard.

The American Chemical Society established a Committee of Chemistry and Public Affairs and sponsored the 1956-1969 study reported in "Cleaning Our Environment: The Chemical Basis for Action," distributed to 70,000 officials, laymen, faculty and students.

In 1966 a report of the Executive Office of Science and Technology (since abolished by the present administration) predicted almost all the energy problems we face today.

The American Association for the Advancement of Science struggled from 1966 to establish their Herbicide Assessment Commission. It fianlly created tremendous impact through the unimpeachable quality of its work, helping to bring an end to the Army's devastation of Vietnamese forests and rice fields.

The APS Forum on Physics and Society was formalized in January, 1972 to advance knowledge interrelating physics and society.

During the summer of 1973 at the "Scientists in the Public Interest" conference in Alta, Utah, representatives from ACS, APS and the Institute of Electrical and Electronic Engineers plus several other professional organizations established a task force to propose a joint program for a "science advisory service" to aid citizens and public-interest groups.

The Biophysical Society has recently set up a system of matchmaking to get unbiased, competent scientists together with interested officials or citizen groups.

And most recently a panel named by the National Academy of Sciences proposed creation of a three-man Council for Science and Technology, having a policy role similar to that of the Council of Economic Advisers, with direct access to the President. It would attend meetings of the National Security Council, advise the Secretary of State, help set priorities for research expenditures and issue an annual public report.

We cite but a few of the programs which are proving constructive. Yet in reviewing these activities one is distinctly impressed with the monumental quantity of work and minimal numbers of hands on deck. Do you believe with us that our strength will come from numbers and union among us? Do enough of us care enough to pitch in? Would you like to express an opinion? We shall attempt to publicize your responses in the next SPEX SPEAKER.

SPEX High Purity Materials

We are pleased to offer a new, expanded Spex catalog of high-purity materials. This list includes many compounds we did not heretofore supply: metal halides, nitrates, sulfates, sulfides, many of which are water-soluble compounds ideal for preparing standard solutions.

Our Analysis Certificate, which accompanies each portion of material shipped, has likewise been elaborated. A quantitative analysis is provided in addition to the emission spectrographic report of all metallic impurities to their detection limits. The percentages of metallic elements in each compound will be found particularly helpful for non-stoichiometric or hydrated materials. Concentrations of suspected anionic impurities are also included.

Intending now to serve not only optical emission spectroscopists but the diverse applications of all laboratory chemists, we have committed the effort and facilities to enable us to prepare a large number of high-purity materials on our own premises. Many are not yet stocked or included in this catalog. If you require compounds not listed here or laboratory quantities above those indicated, we invite your inquiries.

That we have, for the past twenty years, fulfilled our hallmark, "Specialists in Spectroscopy," has long since been well established. Our endeavor is now to earn the additional reputation, "Specialists in Pure Materials."

NOBLE METAL PRICES ARE BASED ON CURRENT MARKET VALUES AND WILL FLUCTUATE ACCORDINGLY

Please be sure to SPECIFY PURITY and FORM for each material ordered.

Material	Formula	Purity	Form	Price ($)
ALUMINUM	Al	6-9s	Sheet, .020" thick	6.04/2g
				20.67/10g
		5-9s+	Rod, 4x75mm	5.43/10g
				31.80/50g
		5-9s	Powder 90-150μ	5.62/10g
				18.97/50g
ALUMINUM FLUORIDE	$AlF_3 \cdot H_2O$	5-9s	Powder	10.07/10g
				38.16/50g
ALUMINUM OXIDE	Al_2O_3	6-9s	Powder	5.83/2g
				19.82/10g
		4-9s+	Powder	13.36/20g
				59.35/100g
ALUMINUM SULFATE	$Al_2(SO_4)_3$	5-9s	Powder	6.89/10g
				28.62/50g
ANTIMONY	Sb	6-9s	Powder	7.00/g
				23.74/5g
		5-9s+	Pieces, irregular	7.63/10g
				25.97/50g
ANTIMONY OXIDE	Sb_2O_3	5-9s+	White Powder	9.33/10g
				31.69/50g
	Sb_2O_5	5-9s	Yellow Powder	5.19/10g
				17.60/50g
ANTIMONY SULFIDE	Sb_2S_3	5-9s	Powder	10.07/10g
				41.98/50g
ARSENIC	As	6-9s	Lumps, Beta-form, air stable	9.33/2g
				31.69/10g
		5-9s+	Pieces, irregular	9.22/5g
				31.16/25g
ARSENIC ACID	$H_3AsO_4 \cdot \frac{1}{2} H_2O$	5-9s	Crystals	5.08/5g
				21.31/25g
ARSENIC OXIDE	As_2O_3	5-9s+	Powder	5.83/5g
				17.50/25g
ARSENIC SULFIDE	As_2S_3	5-9s	Powder	5.94/5g
				24.49/25g

Material	Formula	Purity	Form	Price ($)
BARIUM CARBONATE	$BaCO_3$	5-9s	Powder	9.33/5g
				26.29/25g
BARIUM CHLORIDE	$BaCl_2$	5-9s	Powder	6.47/5g
				22.05/25g
BARIUM FLUORIDE	BaF_2	5-9s	Powder	7.10/5g
				29.68/25g
BARIUM NITRATE	$Ba(NO_3)_2$	5-9s	Powder	9.91/10g
				41.34/50g
BARIUM SULFATE	$BaSO_4$	5-9s	Crystals	8.80/10g
				36.57/50g
BERYLLIUM	Be	4-9s	Flake	10.33/g
				35.90/5g
		3-9s	Chip	5.30/10g
				17.81/50g
BERYLLIUM OXIDE	BeO	5-9s	Powder	8.17/20g
				31.06/100g
BERYLLIUM SULFATE	$BeSO_4 \cdot 4H_2O$	5-9s	Crystals	5.94/10g
				24.49/50g
BISMUTH	Bi	6-9s	Shot, irregular	10.49/50g
				35.72/250g
		6-9s	Powder	8.37/20g
				28.62/100g
BISMUTH OXIDE	Bi_2O_3	5-9s	Powder	7.00/10g
				29.15/50g
BISMUTH OXYCHLORIDE	BiOCl	5-9s	Powder	6.78/10g
				28.09/50g
BISMUTH SULFIDE	Bi_2S_3	5-9s	Powder	8.06/10g
				33.28/50g
BORON	B	5-9s+	Granule, 150μ	127.20/g
		3-9s	Powder	10.16/5g
				34.77/25g
BORIC ACID	H_3BO_3	4-9s	Powder	7.00/50g
				23.85/250g
BORON OXIDE	B_2O_3	5-9s	Powder	7.60/g
				29.15/5g

Material	Formula	Purity	Form	Price ($)
AMMONIUM TETRAFLUOROBORATE	NH_4BF_4	4-9s	Powder	8.69/20g 36.15/100g
CADMIUM	Cd	6-9s	Powder	11.66/10g 39.64/50g
		5-9s+	Splatters	7.58/50g 25.76/250g
CADMIUM CHLORIDE	$CdCl_2$	5-9s	Powder	6.15/20g 25.65/100g
CADMIUM OXIDE	CdO	5-9s+	Powder	13.57/5g 50.35/25g
CADMIUM SULFATE	$CdSO_4 \bullet H_2O$	5-9s	Powder	6.15/20g 25.65/100g
CADMIUM SULFIDE	CdS	5-9s	Powder	7.00/20g 29.15/100g
CALCIUM CARBONATE	$CaCO_3$	5-9s	Powder	7.42/5g 25.44/25g
CALCIUM FLUORIDE	CaF_2	5-9s	Powder	9.33/5g 38.69/25g
CALCIUM SULFATE	$CaSO_4 \bullet 2H_2O$	5-9s	Powder	6.57/5g 27.35/25g
CERIUM	Ce	3-9s+	Ingot	6.78/10g 23.00/50g
CERIUM OXIDE	CeO_2	3-9s+	Powder	5.09/10g 17.49/50g
CEROUS CHLORIDE	$CeCl_3 \bullet 7H_2O$	3-9s+	Powder	4.98/5g 20.99/25g
CEROUS SULFATE	$Ce_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	4.98/5g 20.99/25g
CESIUM CARBONATE	Cs_2CO_3	3-9s	Powder	6.47/10g 21.84/50g
CESIUM CHLORIDE	CsCl	3-9s	Powder	6.47/10g 21.84/50g
CESIUM CHROMATE	Cs_2CrO_4	3-9s	Powder	6.47/10g 21.84/50g
CESIUM NITRATE	$CsNO_3$	3-9s	Powder	5.62/5g 23.37/25g
CESIUM SULFATE	Cs_2SO_4	3-9s	Powder	6.47/5g 26.82/25g
CHROMIUM	Cr	5-9s	Shot, Irregular	8.37/20g 37.84/100g
		5-9s	Flake	6.47/10g 23.00/50g
		4-9s	Powder, 150μ	10.49/50g 35.62/250g
CHROMIUM OXIDE	Cr_2O_3	5-9s	Powder	10.81/5g 36.68/25g
CHROMIUM AMMONIUM SULFATE	$NH_4Cr(SO_4)_2 \bullet 12H_2O$	5-9s	Crystals	6.57/10g 27.45/50g
COBALT	Co	5-9s	Powder	8.50/5g 30.10/25g
		3-9s	27g Rod, 5mm x 15cm	66.78/rod 222.60/5 rods
COBALT CHLORIDE	$CoCl_2 \bullet 6H_2O$	5-9s	Crystals	7.60/10g 29.15/50g
COBALT OXIDE	Co_3O_4	5-9s	Powder	6.89/5g 23.32/25g
COBALT SULFATE	$CoSO_4 \bullet 7H_2O$	5-9s	Crystals	6.35/10g 26.50/50g
COLUMBIUM		(SEE NIOBIUM)		
COPPER	Cu	6-9s	Bars ¾" (70g)	26.50/bar
		5-9s	Rods, 5x150mm (27g)	11.02/rod 37.31/5 rods
		5-9s	Powder	9.96/10g 33.71/50g
COPPER HYDROXYFLUORIDE	Cu(OH)F	4-9s	Powder, boron free	8.37/10g 28.20/50g
COPPER IODIDE	CuI	5-9s+	Powder	7.10/10g 29.68/50g
COPPER OXIDE	CuO	5-9s+	Powder	11.45/5g 47.28/25g
COPPER SULFATE	$CuSO_4 \bullet 5H_2O$	5-9s	Powder	6.47/10g 26.92/50g
DYSPROSIUM	Dy	3-9s	Ingot	5.72/2g 19.50/10g
DYSPROSIUM CHLORIDE	$DyCl_3 \bullet 6H_2O$	3-9s+	Crystals	7.84/5g 32.65/25g
DYSPROSIUM OXIDE	Dy_2O_3	3-9s+	Powder	7.95/5g 26.50/25g
DYSPROSIUM SULFATE	$Dy_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Powder	7.84/5g 32.65/25g
ERBIUM	Er	3-9s	Ingot	7.10/g 24.17/5g
ERBIUM CHLORIDE	$ErCl_3 \bullet 6H_2O$	3-9s+	Crystals	6.89/5g 28.62/25g
ERBIUM OXIDE	Er_2O_3	3-9s+	Powder	7.21/5g 24.17/25g
ERBIUM SULFATE	$Er_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	6.89/5g 28.62/25g
EUROPIUM	Eu	3-9s	Ingot	24.17/g 101.76/5g
EUROPIUM CHLORIDE	$EuCl_3 \bullet 6H_2O$	3-9s	Crystals	10.92/2g 45.37/10g
EUROPIUM OXIDE	Eu_2O_3	5-9s	Powder	78.44/g
		3-9s	Powder	9.01/g 30.95/5g
EUROPIUM SULFATE	$Eu_2(SO_4)_3 \bullet 8H_2O$	3-9s	Crystals	10.92/2g 45.05/10g
GADOLINIUM	Gd	4-9s	Powder, 250-450μ	13.46/g 45.58/5g
GADOLINIUM CHLORIDE	$GdCl_3 \bullet 6H_2O$	3-9s+	Crystals	5.62/5g 23.37/25g
GADOLINIUM OXIDE	Gd_2O_3	5-9s	Powder	18.55/g 77.38/5g
		3-9s+	Powder	6.48/10g 23.15/50g
GADOLINIUM SULFATE	$Gd_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	5.62/5g 23.37/25g
GALLIUM	Ga	6-9s	Splatter	8.27/g 28.09/5g
GALLIUM OXIDE	Ga_2O_3	6-9s	Powder 1-2μ	7.74/g 26.50/5g
GALLIUM SULFATE	$Ga_2(SO_4)_3$	5-9s	Powder	6.57/2g 27.03/10g
GERMANIUM	Ge	5-9s+	Pieces, Irregular	5.51/5g 18.87/25g
		3-9s	Powder	10.15/10g 34.45/50g
AMMONIUM HEXAFLUOROGERMANATE	$(NH_4)_2GeF_6$	4-9s	Powder	9.33/10g 39.01/50g
GERMANIUM OXIDE	GeO_2	5-9s	Powder	8.37/25g 28.51/100g
GOLD	Au	5-9s	Powder	17.81/g 74.20/5g
		5-9s	Splatter	17.81/g 74.20/5g
AMMONIUM CHLOROAURATE	NH_4AuCl_4	5-9s	Powder	17.38/g 72.30/5g
HAFNIUM	Hf	3-9s+	Wire (.125mm) contains 2-3% Zr	7.95/2g 26.92/10g
		3-9s	Sponge (contains 1-3% Zr)	9.54/5g 26.71/25g
HAFNIUM OXIDE	HfO_2	3-9s	Powder 100 ppm Zr	9.31/g 31.69/5g
HAFNIUM SULFATE	$Hf(SO_4)_2 \bullet 4H_2O$	3-9s	Crystals	9.96/2g 40.61/10g
HOLMIUM	Ho	3-9s	Ingot	8.80/g 29.68/5g
		3-9s	Powder	9.43/g 31.91/5g
HOLMIUM CHLORIDE	$HoCl_3 \bullet 6H_2O$	3-9s+	Crystals	9.22/5g 38.48/25g
HOLMIUM OXIDE	Ho_2O_3	3-9s+	Powder	10.92/5g 37.31/25g
HOLMIUM SULFATE	$Ho_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	9.22/5g 38.48/25g

Material	Formula	Purity	Form	Price ($)
INDIUM	In	6-9s	Splatter	8.37/5g 28.62/25g
		5-9s	Powder	7.31/5g 25.12/25g
INDIUM CHLORIDE	$InCl_3$	5-9s	Crystals	6.04/5g 25.12/25g
INDIUM OXIDE	In_2O_3	5-9s+	Powder	13.67/10g 56.71/50g
INDIUM SULFATE	$In_2(SO_4)_3$	5-9s	Crystals	9.33/10g 39.11/50g
INDIUM SULFIDE	In_2S_3	5-9s	Powder	6.68/5g 27.77/25g
IODINE	I_2	5-9s	Crystals	6.36/20g 21.62/100g
IRIDIUM	Ir	5-9s	Sponge	73.14/g
		3-9s	Powder	47.40/g
AMMONIUM HEXACHLOROIRIDATE (IV)	$(NH_4)_2IrCl_6$	3-9s	Powder	76.32/g
IRON	Fe	5-9s	Sponge	6.47/10g 21.84/50g
		5-9s	Powder 150µ	7.63/10g 25.65/50g
		5-9s	Rod, 5x150mm (24g)	17.49/rod 73.14/5 rods
FERROUS AMMONIUM SULFATE	$(NH_4)_2Fe(SO_4)_2 \bullet 6H_2O$	5-9s	Crystals	5.94/20g 24.49/100g
IRON OXIDE	Fe_2O_3	5-9s	Powder	8.80/10g 29.79/50g
LANTHANUM	La	3-9s	Powder 150µ	10.92/g 37.31/5g
LANTHANUM BROMIDE	$LaBr_3 \bullet 7H_2O$	5-9s	Crystals	5.94/20g 24.50/100g
LANTHANUM CHLORIDE	$LaCl_3 \bullet 7H_2O$	5-9s	Crystals	5.94/20g 24.49/100g
LANTHANUM FLUORIDE	LaF_3	5-9s	Powder	5.72/10g 23.96/50g
LANTHANUM NITRATE	$La(NO_3)_3 \bullet 6H_2O$	5-9s	Crystals	5.94/20g 24.50/100g
LANTHANUM OXIDE	La_2O_3	5-9s+	Powder	4.88/20g 16.64/100g
LANTHANUM SULFATE	$La_2(SO_4)_3 \bullet 9H_2O$	5-9s	Crystals	5.94/20g 24.49/100g
LEAD	Pb	6-9s	Shot, irregular	9.35/50g 31.80/250g
		5-9s	Powder	9.33/20g 31.80/100g
LEAD ACETATE	$Pb(C_2H_3O_2)_2$	5-9s	Crystals	6.47/20g 26.82/100g
LEAD CHLORIDE	$PbCl_2$	5-9s	Powder	7.21/10g 30.32/50g
LEAD NITRATE	$Pb(NO_3)_2$	5-9s	Crystals	6.47/20g 26.82/100g
LEAD OXIDE	PbO	5-9s+	Powder	6.57/10g 22.15/50g
LEAD SULFATE	$PbSO_4$	5-9s	Crystals	6.47/20g 26.82/100g
LEAD SULFIDE	PbS	4-9s	Powder	9.01/10g 30.74/50g
LITHIUM CARBONATE	Li_2CO_3	5-9s	Powder	8.55/10g 28.94/50g 51.41/100g 89.11/200g 174.92/lb
LITHIUM FLUORIDE	LiF	3-9s+	Powder	9.01/5g 30.74/25g
LITHIUM SULFATE	Li_2SO_4	5-9s	Powder	7.84/10g 32.65/50g
LUTETIUM	Lu	3-9s	Ingot	163.24/g
		3-9s	Powder	86.39g
LUTETIUM CHLORIDE	$LuCl_3 \bullet 6H_2O$	3-9s+	Crystals	19.29/g 79.50/5g
LUTETIUM OXIDE	Lu_2O_3	3-9s+	Powder	29.47/g 100.17/5g
LUTETIUM SULFATE	$Lu_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	19.29/g 80.03/5g
MAGNESIUM	Mg	4-9s+	Rods, 3x75mm (1.1g)	6.36/20g 21.41/100g
MAGNESIUM FLUORIDE	MgF_2	5-9s	Powder	8.16/5g 33.92/25g
MAGNESIUM OXIDE	MgO	5-9s+	Powder	10.49/5g 43.72/25g
MAGNESIUM SULFATE	$MgSO_4$	5-9s	Powder	9.33/10g 38.48/50g
MANGANESE	Mn	4-9s+	Flake	9.33/50g 31.80/250g
		3-9s+	Powder	4.66/100g 15.90/500g
MANGANESE CHLORIDE	$MnCl_2 \bullet 4H_2O$	4-9s+	Crystals	8.69/20g 36.15/100g
MANGANESE OXIDE	MnO_2	5-9s+	Powder	11.66/5g 39.64/25g
MANGANESE SULFATE	$MnSO_4 \bullet 5H_2O$	5-9s	Crystals	4.03/20g 16.96/100g
MANGANESE SULFIDE	MnS	4-9s	Powder	9.22/2g 31.16/10g
MERCURY	Hg	9-9s	Liquid	9.54/20g 31.80/100g
		7-9s	Liquid	7.53/50g 25.65/250g
MERCURIC CHLORIDE	$HgCl_2$	5-9s+	Crystals	6.47/20g 26.82/100g
MERCURIC IODIDE	HgI_2	5-9s	Powder	7.84/20g 32.54/100g
MERCURIC OXIDE	HgO	5-9s+	Powder	5.83/2g 23.45/10g
MERCURIC SULFIDE	HgS	5-9s	Powder	7.31/20g 30.71/100g
MOLYBDENUM	Mo	4-9s+	Powder	9.32/100g 31.80/500g
		4-9s+	Rods, 28g/rod	18.55/rod 77.27/5
MOLYBDENUM OXIDE	MoO_3	5-9s	Powder	8.69/5g 36.04/25g
AMMONIUM MOLYBDATE	$(NH_4)_6Mo_7O_{24} \bullet 4H_2O$	5-9s	Powder	10.81/5g 34.50/25g
NEODYMIUM	Nd	3-9s	Powder 210-840µ	23.21/g 66.78/5g
NEODYMIUM CHLORIDE	$NdCl_3 \bullet 6H_2O$	3-9s	Crystals	5.30/10g 22.15/50g
NEODYMIUM OXIDE	Nd_2O_3	5-9s	Powder	12.40/g 41.98/5g
		3-9s	Powder	5.72/10g 19.50/50g
NEODYMIUM SULFATE	$Nd_2(SO_4)_3 \bullet 8H_2O$	3-9s	Powder	9.22/20g 35.49/100g
NICKEL	Ni	5-9s	Powder	8.43/10g 28.83/50g
		5-9s	Wire 3mm	69.96/10g 291.50/50g
		4-9s	Powder	4.66/100g 15.90/500g
NICKEL CHLORIDE	$NiCl_2 \bullet 6H_2O$	5-9s	Crystals	6.47/20g 22.15/100g
NICKEL OXIDE	NiO	5-9s	Powder	8.59/20g 29.47/100g
NICKEL SULFATE	$NiSO_4 \bullet 6H_2O$	5-9s	Crystals	5.94/20g 24.49/100g
NIOBIUM	Nb	5-9s+	Powder	7.42/20g 25.44/100g
AMMONIUM HEXAFLUORONIOBATE (V)	NH_4NbF_6	4-9s	Powder	10.18/10g 47.40/50g
NIOBIUM OXIDE	Nb_2O_5	4-9s+	Powder	9.86/50g 33.81/250g
PALLADIUM	Pd	5-9s	Powder	31.80/g
		3-9s	Powder	11.55/g 47.70/5g

Material	Formula	Purity	Form	Price ($)
AMMONIUM TETRACHLORO-PALLADITE (II)	$(NH_4)_2PdCl_4$	5-9s	Crystals	17.49/g 73.46/5g
PALLADIUM IODIDE	PdI_2	5-9s	Powder	13.57/g 56.60/5g
PALLADIUM OXIDE	PdO	4-9s	Powder	12.40/g 41.98/5g
PALLADIUM SULFIDE	PdS	5-9s	Powder	31.48/g 131.44/5g
AMMONIUM PHOSPHATE	$NH_4H_2PO_4$	5-9s	Powder	10.49/100g 35.62/500g
PLATINUM	Pt	5-9s	Powder	31.38/g 131.44/5g
AMMONIUM CHLOROPLATINATE (IV)	$(NH_4)_2PtCl_6$	5-9s	Powder	18.66/g 77.38/5g
PLATINUM SULFIDE	PtS_2	5-9s	Powder	36.46/g 151.58/5g
POTASSIUM CARBONATE	$K_2CO_3 \bullet xH_2O$	5-9s	Powder	10.49/20g 35.62/100g
POTASSIUM CHLORIDE	KCl	5-9s+	Powder	7.31/5g 25.02/25g
POTASSIUM NITRATE	KNO_3	5-9s	Crystals	6.78/10g 27.98/50g
POTASSIUM SULFATE	K_2SO_4	5-9s	Crystals	6.78/10g 27.98/50g
PRASEODYMIUM	Pr	3-9s	Wire 1mm	150.52/g
		3-9s	Powder	20.99/2g 87.45/10g
PRASEODYMIUM CHLORIDE	$PrCl_3 \bullet 7H_2O$	3-9s+	Crystals	6.89/10g 28.62/50g
PRASEODYMIUM OXIDE	Pr_6O_{11}	5-9s	Powder	12.30/g 41.98/5g
		3-9s+	Powder	9.12/20g 30.74/100g
PRASEODYMIUM SULFATE	$Pr_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	5.72/10g 23.96/50g
RHENIUM	Re	4-9s+	Powder	11.65/g 47.70/5g
AMMONIUM PERRHENATE	NH_4ReO_4	4-9s+	Granular	7.63/g 25.78/5g
RHODIUM	Rh	5-9s	Powder	93.28/g 279.84/5g
		4-9s	Powder	24.59/g 83.74/5g
AMMONIUM CHLORORHODATE (III)	$(NH_4)_3RhCl_6$	3-9s	Powder	21.62/g 90.10/5g
RHODIUM OXIDE	RhO_2	4-9s	Powder	55.12/g
RUBIDIUM CHLORIDE	RbCl	3-9s	Powder	6.47/10g 21.84/50g
RUBIDIUM SULFATE	Rb_2SO_4	3-9s	Powder	7.84/10g 32.65/50g
RUTHENIUM	Ru	3-9s+	Powder	8.80/g 30.10/5g
SAMARIUM	Sm	3-9s	Powder 75-150μ	19.08/g 64.56/5g
SAMARIUM CHLORIDE	$SmCl_3 \bullet 6H_2O$	3-9s+	Powder	6.47/10g 26.82/50g
SAMARIUM OXIDE	Sm_2O_3	3-9s+	Powder	5.41/10g 17.81/50g
SAMARIUM SULFATE	$Sm_2(SO_4)_3 \bullet 8H_2O$	3-9s+	Crystals	8.37/20g 34.98/100g
SCANDIUM	Sc	3-9s+	Ingot	231.60/g
		3-9s	Powder	116.60/g
SCANDIUM OXIDE	Sc_2O_3	5-9s	Powder	14.31/g 59.68/5g
		3-9s	Powder	7.42/g 30.95/5g
SCANDIUM SULFATE	$Sc_2(SO_4)_3$	5-9s	Crystals	7.42/g 30.95/5g
SELENIUM	Se	6-9s	Pellets	7.42/20g 25.44/100g
		5-9s+	Pellets	11.13/50g 37.74/250g
SELENIUM OXIDE	SeO_2	5-9s+	Powder	7.68/5g 26.18/25g
SILICON	Si	6-9s+	Pieces, irregular	6.04/10g 20.57/50g
		6-9s	Powder	7.00/5g 29.15/25g
AMMONIUM HEXAFLUOROSILICATE	$(NH_4)_2SiF_6$	5-9s	Powder	8.37/20g 34.98/100g
SILICON OXIDE	SiO_2	6-9s+	Powder	10.71/20g 35.35/100g
SILVER	Ag	6-9s	Shot	6.57/5g 22.37/25g
		5-9s	Powder	8.48/2g 28.94/10g
SILVER CHLORIDE	AgCl	6-9s+	Powder	11.66/5g 39.64/25g
SILVER NITRATE	$AgNO_3$	5-9s	Crystals	10.60/10g 43.99/50g
SILVER SULFATE	Ag_2SO_4	5-9s	Crystals	11.39/10g 47.28/50g
SODIUM CARBONATE	Na_2CO_3	5-9s	Powder	8.80/5g 36.46/25g
SODIUM CHLORIDE	NaCl	5-9s	Powder	7.63/10g 25.86/50g
SODIUM NITRATE	$NaNO_3$	5-9s	Powder	7.55/5g 31.69/25g
SODIUM SULFATE	Na_2SO_4	5-9s	Powder	8.50/5g 35.51/25g
STRONTIUM CARBONATE	$SrCO_3$	5-9s	Powder	11.13/5g 37.74/25g
STRONTIUM CHLORIDE	$SrCl_2$	5-9s	Powder	7.95/2g 27.14/10g
STRONTIUM FLUORIDE	SrF_2	5-9s	Powder	8.27/2g 28.09/10g
STRONTIUM NITRATE	$Sr(NO_3)_2 \bullet 4H_2O$	5-9s	Powder	6.36/10g 26.50/50g
STRONTIUM SULFATE	$SrSO_4$	5-9s	Powder	9.22/10g 38.48/50g
TANTALUM	Ta	4-9s+	Powder	6.78/20g 22.90/100g
AMMONIUM HEXAFLUOROTANTALATE	NH_4TaF_6	4-9s	Powder	7.53/10g 31.27/50g
TANTALUM OXIDE	Ta_2O_5	4-9s	Powder	10.76/10g 34.98/50g
TELLURIUM	Te	6-9s	Bars	10.60/10g 34.98/50g
		5-9s+	Pieces	5.41/20g 18.13/100g
TELLURIUM OXIDE	TeO_2	5-9s	Powder	6.68/2g 22.68/10g
TERBIUM	Tb	3-9s	Ingot	16.96/g 46.22/5g
		3-9s	Powder	17.81/g 60.42/5g
TERBIUM CHLORIDE	$TbCl_3 \bullet 6H_2O$	3-9s	Crystals	19.19/5g 80.56/25g
TERBIUM OXIDE	Tb_4O_7	5-9s	Powder	42.61/g 143.10/5g
		3-9s	Powder	8.48/g 28.83/5g
TERBIUM SULFATE	$Tb_2(SO_4)_3 \bullet 8H_2O$	3-9s	Crystals	17.46/5g 77.17/25g
THALLIUM	Tl	5-9s	Rods (25g) 10x33mm	14.63/25g 50.88/125g
THALLIUM CHLORIDE	TlCl	5-9s	Powder	7.10/10g 29.68/50g
THALLIUM NITRATE	$TlNO_3$	5-9s	Powder	5.78/10g 24.11/50g

Material	Formula	Purity	Form	Price ($)
THALLIUM OXIDE	Tl_2O_3	5-9s+	Powder	6.47/10g 21.73/50g
THALLIUM SULFATE	Tl_2SO_4	5-9s	Crystals	6.68/10g 27.98/50g
THORIUM	Th	3-9s	Powder	9.12/20g 30.95/100g
THORIUM OXIDE	ThO_2	4-9s	Powder	9.80/10g 33.07/50g
THORIUM SULFATE	$Th(SO_4)_2 \cdot 4H_2O$	4-9s	Powder	7.95/5g 33.28/25g
THULIUM	Tm	3-9s	Powder 250-350μ	67.31/g
THULIUM CHLORIDE	$TmCl_3 \cdot 6H_2O$	3-9s+	Crystals	8.90/g 36.89/5g
THULIUM OXIDE	Tm_2O_3	3-9s+	Powder	18.87/g 64.13/5g
THULIUM SULFATE	$Tm_2(SO_4)_3 \cdot 8H_2O$	3-9s+	Crystals	8.90/g 36.89/5g
TIN	Sn	6-9s	Pellets	7.63/10g 25.65/50g
		6-9s	Powder	9.33/5g 31.80/25g
TIN OXIDE	SnO_2	6-9s+	Powder	11.66/5g 39.64/25g
TIN SULFIDE	SnS_2	5-9s	Powder	8.06/5g 33.71/25g
TITANIUM	Ti	3-9s+	Sponge	6.04/20g 20.46/100g
		3-9s	Powder	5.83/10g 19.82/50g
AMMONIUM HEXOFLUOROTITANATE	$(NH_4)_2TiF_6$	4-9s	Powder	8.37/20g 34.98/100g
TITANIUM OXIDE	TiO_2	4-9s	Powder	5.09/20g 17.49/100g
TUNGSTEN	W	4-9s	Powder	3.50/100g 11.87/500g
		5-9s	Powder, Low Mo	8.37/10g 27.87/50g
TUNGSTEN OXIDE	WO_3	4-9s+	Powder	4.66/100g 15.90/500g
URANIUM	U	4-9s	Rods, ¼"x3", 45g	39.75/rod
URANIUM OXIDE	U_3O_8	4-9s	Powder	10.07/5g 28.20/25g

Material	Formula	Purity	Form	Price ($)
URANYL SULFATE	$UO_2SO_4 \cdot 3H_2O$	4-9s	Crystals	8.59/10g 35.72/50g
VANADIUM	V	3-9s	Pellets	9.12/20g 30.95/100g
VANADIUM OXIDE	V_2O_5	3-9s+	Powder	8.59/10g 24.27/50g
		4-9s+	Powder	3.92/g 12.93/5g
YTTRIUM	Y	3-9s	Ingot	5.30/2g 17.81/10g
YTTRIUM CHLORIDE	$YCl_3 \cdot 6H_2O$	5-9s	Crystals	9.43/5g 39.11/25g
YTTRIUM OXIDE	Y_2O_3	6-9s	Powder	5.83/g 19.82/5g
		5-9s	Powder 1-2μ	5.30/2g 17.81/10g
YTTRIUM SULFATE	$Y_2(SO_4)_3 \cdot 8H_2O$	5-9s	Crystals	9.43/5g 39.11/25g
YTTERBIUM	Yb	3-9s	Powder [illegible]	12.40/g 41.96/5g
YTTERBIUM CHLORIDE	$YbCl_3 \cdot 6H_2O$	3-9s	Crystals	8.37/5g 34.66/25g
YTTERBIUM OXIDE	Yb_2O_3	3-9s	Powder	5.19/2g 17.49/10g
YTTERBIUM SULFATE	$Yb_2(SO_4)_3 \cdot 8H_2O$	3-9s	Crystals	8.37/5g 34.66/25g
ZINC	Zn	5-9s+	Splatter	5.19/20g 17.49/100g
		6-9s	Powder	7.00/20g 23.74/100g
ZINC OXIDE	ZnO	4-9s+	Powder	9.33/100g 31.80/500g
ZINC SULFATE	$ZnSO_4 \cdot 7H_2O$	5-9s	Crystals	4.98/20g 21.00/100g
ZINC SULFIDE	ZnS	5-9s	Powder	5.51/10g 22.79/50g
ZIRCONIUM	Zr	4-9s	Rod 3x100mm	27.98/rod
		3-9s+	Sponge	10.49/20g 35.62/100g
ZIRCONIUM OXIDE	ZrO_2	3-9s+	Powder low Hf	12.83/20g 43.76/100g
ZIRCONIUM SULFATE	$Zr(SO_4)_2 \cdot 4H_2O$	3-9s+	Powder	6.89/10g 28.62/50g

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