= Platinum =

Platinum is a chemical element with symbol Pt and atomic number 78 . It is a dense , malleable , ductile , highly unreactive , precious , gray @-@ white transition metal . Its name is derived from the Spanish term platina , which is literally translated into " little silver " .

Platinum is a member of the platinum group of elements and group 10 of the periodic table of elements . It has six naturally occurring isotopes . It is one of the rarer elements in Earth 's crust with an average abundance of approximately 5 ?g / kg . It occurs in some nickel and copper ores along with some native deposits , mostly in South Africa , which accounts for 80 % of the world production . Because of its scarcity in Earth 's crust , only a few hundred tonnes are produced annually , and given its important uses , it is highly valuable and is a major precious metal commodity .

Platinum is one of the least reactive metals . It has remarkable resistance to corrosion , even at high temperatures , and is therefore considered a noble metal . Consequently , platinum is often found chemically uncombined as native platinum . Because it occurs naturally in the alluvial sands of various rivers , it was first used by pre @-@ Columbian South American natives to produce artifacts . It was referenced in European writings as early as 16th century , but it was not until Antonio de Ulloa published a report on a new metal of Colombian origin in 1748 that it began to be investigated by scientists .

Platinum is used in catalytic converters , laboratory equipment , electrical contacts and electrodes , platinum resistance thermometers , dentistry equipment , and jewelry . Being a heavy metal , it leads to health issues upon exposure to its salts ; but due to its corrosion resistance , metallic platinum has not been linked to adverse health effects . Compounds containing platinum , such as cisplatin , oxaliplatin and carboplatin , are applied in chemotherapy against certain types of cancer .

= = Characteristics = =

= = = Physical = = =

Pure platinum is a lustrous , ductile , and malleable , silver @-@ white metal . Platinum is more ductile than gold , silver or copper , thus being the most ductile of pure metals , but it is less malleable than gold . The metal has excellent resistance to corrosion , is stable at high temperatures and has stable electrical properties . Platinum reacts with oxygen slowly at very high temperatures . It reacts vigorously with fluorine at 500 ° C (932 ° F) to form tetrafluoride . It is also attacked by chlorine , bromine , iodine , and sulfur . Platinum is insoluble in hydrochloric and nitric acid , but dissolves in hot aqua regia to form chloroplatinic acid , H_2PtCl_6 .

Its physical characteristics and chemical stability make it useful for industrial applications . Its resistance to wear and tarnish is well suited to use in fine jewelry .

= = = Chemical = = =

The most common oxidation states of platinum are + 2 and + 4 . The + 1 and + 3 oxidation states are less common , and are often stabilized by metal bonding in bimetallic (or polymetallic) species . As is expected , tetracoordinate platinum (II) compounds tend to adopt 16 @-@ electron square planar geometries . Although elemental platinum is generally unreactive , it dissolves in hot aqua regia to give aqueous chloroplatinic acid (H_2PtCl_6) :

$Pt + 4 HNO_3 + 6 HCl \rightarrow H_2PtCl_6 + 4 NO_2 + 4 H_2O$

As a soft acid , platinum has a great affinity for sulfur , such as on dimethyl sulfoxide (DMSO) ; numerous DMSO complexes have been reported and care should be taken in the choice of reaction solvent .

= = = Isotopes = = =

Platinum has six naturally occurring isotopes : 190Pt , 192Pt , 194Pt , 195Pt , 196Pt , and 198Pt . The most abundant of these is 195Pt , comprising 33 @.@ 83 % of all platinum . It is the only stable isotope with a non @-@ zero spin ; with a spin of 1 / 2 , 195Pt satellite peaks are often observed in 1H and 31P NMR spectroscopy (i.e. , Pt @-@ phosphine and Pt @-@ alkyl complexes) . 190Pt is the least abundant at only 0 @.@ 01 % . Of the naturally occurring isotopes , only 190Pt is unstable , though it decays with a half @-@ life of 6 @.@ 5 × 1011 years , causing an activity of 15 Bq / kg of natural platinum . 198Pt can undergo alpha decay , but its decay has never been observed (the half @-@ life is known to be longer than 3 @.@ 2 × 1014 years) ; therefore , it is considered stable . Platinum also has 31 synthetic isotopes ranging in atomic mass from 166 to 202 , making the total number of known isotopes 37 . The least stable of these is 166Pt , with a half @-@ life of 300 μs , whereas the most stable is 193Pt with a half @-@ life of 50 years . Most platinum isotopes decay by some combination of beta decay and alpha decay . 188Pt , 191Pt , and 193Pt decay primarily by electron capture . 190Pt and 198Pt have double beta decay paths .

= = = Occurrence = = =

Platinum is an extremely rare metal , occurring at a concentration of only 0 @.@ 005 ppm in Earth 's crust . It is sometimes mistaken for silver (Ag) . Platinum is often found chemically uncombined as native platinum and as alloy with the other platinum @-@ group metals and iron mostly . Most often the native platinum is found in secondary deposits in alluvial deposits . The alluvial deposits used by pre @-@ Columbian people in the Chocó Department , Colombia are still a source for platinum @-@ group metals . Another large alluvial deposit is in the Ural Mountains , Russia , and it is still mined .

In nickel and copper deposits , platinum @-@ group metals occur as sulfides (e.g. (Pt , Pd) S) , tellurides (e.g. PtBiTe) , antimonides (PdSb) , and arsenides (e.g. PtAs2) , and as end alloys with nickel or copper . Platinum arsenide , sperrylite (PtAs2) , is a major source of platinum associated with nickel ores in the Sudbury Basin deposit in Ontario , Canada . At Platinum , Alaska , about 17 @,@ 000 kg (550 @,@ 000 ozt) had been mined between 1927 and 1975 . The mine ceased operations in 1990 . The rare sulfide mineral cooperite , (Pt , Pd , Ni) S , contains platinum along with palladium and nickel . Cooperite occurs in the Merensky Reef within the Bushveld complex , Gauteng , South Africa .

In 1865 , chromites were identified in the Bushveld region of South Africa , followed by the discovery of platinum in 1906 . The largest known primary reserves are in the Bushveld complex in South Africa . The large copper ? nickel deposits near Norilsk in Russia , and the Sudbury Basin , Canada , are the two other large deposits . In the Sudbury Basin , the huge quantities of nickel ore processed make up for the fact platinum is present as only 0 @.@ 5 ppm in the ore . Smaller reserves can be found in the United States , for example in the Absaroka Range in Montana . In 2010 , South Africa was the top producer of platinum , with an almost 77 % share , followed by Russia at 13 % ; world production in 2010 was 192 @,@ 000 kg (423 @,@ 000 lb) .

Platinum deposits are present in the state of Tamil Nadu , India. and a MOU has been signed between Geological Survey of India with TAMIN ? Tamil Nadu Minerals Ltd .

Platinum exists in higher abundances on the Moon and in meteorites . Correspondingly , platinum is found in slightly higher abundances at sites of bolide impact on Earth that are associated with resulting post @-@ impact volcanism , and can be mined economically ; the Sudbury Basin is one such example .

= = Compounds = =

= = = Halides = = =

Hexachloroplatinic acid mentioned above is probably the most important platinum compound , as it serves as the precursor for many other platinum compounds . By itself , it has various applications in

photography , zinc etchings , indelible ink , plating , mirrors , porcelain coloring , and as a catalyst .

Treatment of hexachloroplatinic acid with an ammonium salt , such as ammonium chloride , gives ammonium hexachloroplatinate , which is relatively insoluble in ammonium solutions . Heating this ammonium salt in the presence of hydrogen reduces it to elemental platinum . Potassium hexachloroplatinate is similarly insoluble , and hexachloroplatinic acid has been used in the determination of potassium ions by gravimetry .

When hexachloroplatinic acid is heated , it decomposes through platinum (IV) chloride and platinum (II) chloride to elemental platinum , although the reactions do not occur stepwise :

(H3O) 2PtCl6 · nH2O ? PtCl4 + 2 HCl + (n + 2) H2O

PtCl4 ? PtCl2 + Cl2

PtCl2 ? Pt + Cl2

All three reactions are reversible . Platinum (II) and platinum (IV) bromides are known as well . Platinum hexafluoride is a strong oxidizer capable of oxidizing oxygen .

= = = Oxides = = =

Platinum (IV) oxide , PtO2 , also known as Adams ' catalyst , is a black powder that is soluble in KOH solutions and concentrated acids . PtO2 and the less common PtO both decompose upon heating . Platinum (II , IV) oxide , Pt3O4 , is formed in the following reaction :

2 Pt2 + + Pt4 + + 4 O2 ? ? Pt3O4

= = = Other compounds = = =

Unlike palladium acetate , platinum (II) acetate is not commercially available . Where a base is desired , the halides have been used in conjunction with sodium acetate . The use of platinum (II) acetylacetonate has also been reported .

Several barium platinides have been synthesized in which platinum exhibits negative oxidation states ranging from ? 1 to ? 2 . These include BaPt , Ba

3Pt

2 , and Ba

2Pt . Caesium platinide , Cs

2Pt , a dark @-@ red transparent crystalline compound has been shown to contain Pt2 ? anions . Platinum also exhibits negative oxidation states at surfaces reduced electrochemically . The negative oxidation states exhibited by platinum are unusual for metallic elements , and they are attributed to the relativistic stabilization of the 6s orbitals .

Zeise 's salt , containing an ethylene ligand , was one of the first organometallic compounds discovered . Dichloro (cycloocta @-@ 1 @,@ 5 @-@ diene) platinum (II) is a commercially available olefin complex , which contains easily displaceable cod ligands (" cod " being an abbreviation of 1 @,@ 5 @-@ cyclooctadiene) . The cod complex and the halides are convenient starting points to platinum chemistry .

Cisplatin , or cis @-@ diamminedichloroplatinum (II) is the first of a series of square planar platinum (II) -containing chemotherapy drugs , including carboplatin and oxaliplatin . These compounds are capable of crosslinking DNA , and kill cells by similar pathways to alkylating chemotherapeutic agents . (Side effects of cisplatin include nausea and vomiting , hair loss , tinnitus , hearing loss , and nephrotoxicity .)

= = History = =

= = = Early uses = = =

Archaeologists have discovered traces of platinum in the gold used in ancient Egyptian tombs and hieroglyphics as early as 1200 BC . However , the extent of early Egyptians ' knowledge of the metal

is unclear . It is quite possible they did not recognize there was platinum in their gold .

The metal was used by pre @-@ Columbian Americans near modern @-@ day Esmeraldas , Ecuador to produce artifacts of a white gold @-@ platinum alloy . They employed a relatively sophisticated system of powder metallurgy . The platinum used in such objects was not the pure element , but rather a naturally occurring mixture of the platinum group metals , with small amounts of palladium , rhodium , and iridium .

= = = European discovery = = =

The first European reference to platinum appears in 1557 in the writings of the Italian humanist Julius Caesar Scaliger as a description of an unknown noble metal found between Darién and Mexico , " which no fire nor any Spanish artifice has yet been able to liquefy " . From their first encounters with platinum , the Spanish generally saw the metal as a kind of impurity in gold , and it was treated as such . It was often simply thrown away , and there was an official decree forbidding the adulteration of gold with platinum impurities .

In 1741 , Charles Wood , a British metallurgist , found various samples of Colombian platinum in Jamaica , which he sent to William Brownrigg for further investigation . Antonio de Ulloa , also credited with the discovery of platinum , returned to Spain from the French Geodesic Mission in 1746 after having been there for eight years . His historical account of the expedition included a description of platinum as being neither separable nor calcinable . Ulloa also anticipated the discovery of platinum mines . After publishing the report in 1748 , Ulloa did not continue to investigate the new metal . In 1758 , he was sent to superintend mercury mining operations in Huancavelica .

In 1750 , after studying the platinum sent to him by Wood , Brownrigg presented a detailed account of the metal to the Royal Society , stating that he had seen no mention of it in any previous accounts of known minerals . Brownrigg also made note of platinum 's extremely high melting point and refractoriness toward borax . Other chemists across Europe soon began studying platinum , including Andreas Sigismund Marggraf , Torbern Bergman , Jöns Jakob Berzelius , William Lewis , and Pierre Macquer . In 1752 , Henrik Scheffer published a detailed scientific description of the metal , which he referred to as " white gold " , including an account of how he succeeded in fusing platinum ore with the aid of arsenic . Scheffer described platinum as being less pliable than gold , but with similar resistance to corrosion .

= = = Means of malleability = = =

Carl von Sickingen researched platinum extensively in 1772 . He succeeded in making malleable platinum by alloying it with gold , dissolving the alloy in hot aqua regia , precipitating the platinum with ammonium chloride , igniting the ammonium chloroplatinate , and hammering the resulting finely divided platinum to make it cohere . Franz Karl Achard made the first platinum crucible in 1784 . He worked with the platinum by fusing it with arsenic , then later volatilizing the arsenic .

Because the other platinum @-@ family members were not discovered yet (platinum was the first in the list) , Scheffer and Sickingen made the false assumption that due to its hardness ? which is slightly more than for pure iron ? platinum would be a relatively non @-@ pliable material , even brittle at times , when in fact its ductility and malleability are close to that of gold . Their assumptions could not be avoided because the platinum they experimented with was highly contaminated with minute amounts of platinum @-@ family elements such as osmium and iridium , amongst others , which embrittled the platinum alloy . Alloying this impure platinum residue called " plyoxen " with gold was the only solution at the time to obtain a pliable compound , but nowadays , very pure platinum is available and extremely long wires can be drawn from pure platinum , very easily , due to its crystalline structure , which is similar to that of many soft metals .

In 1786 , Charles III of Spain provided a library and laboratory to Pierre @-@ François Chabaneau to aid in his research of platinum . Chabaneau succeeded in removing various impurities from the ore , including gold , mercury , lead , copper , and iron . This led him to believe he was working with

a single metal , but in truth the ore still contained the yet @-@ undiscovered platinum @-@ group metals . This led to inconsistent results in his experiments . At times , the platinum seemed malleable , but when it was alloyed with iridium , it would be much more brittle . Sometimes the metal was entirely incombustible , but when alloyed with osmium , it would volatilize . After several months , Chabaneau succeeded in producing 23 kilograms of pure , malleable platinum by hammering and compressing the sponge form while white @-@ hot . Chabeneau realized the infusibility of platinum would lend value to objects made of it , and so started a business with Joaquín Cabezas producing platinum ingots and utensils . This started what is known as the " platinum age " in Spain .

In 2007 , Gerhard Ertl won the Nobel Prize in Chemistry for determining the detailed molecular mechanisms of the catalytic oxidation of carbon monoxide over platinum (catalytic converter) .

= = Production = =

Platinum , along with the rest of the platinum @-@ group metals , is obtained commercially as a by @-@ product from nickel and copper mining and processing . During electrorefining of copper , noble metals such as silver , gold and the platinum @-@ group metals as well as selenium and tellurium settle to the bottom of the cell as " anode mud " , which forms the starting point for the extraction of the platinum @-@ group metals .

If pure platinum is found in placer deposits or other ores , it is isolated from them by various methods of subtracting impurities . Because platinum is significantly denser than many of its impurities , the lighter impurities can be removed by simply floating them away in a liquid . Platinum is paramagnetic , whereas nickel and iron are both ferromagnetic . These two impurities are thus removed by running an electromagnet over the mixture . Because platinum has a higher melting point than most other substances , many impurities can be burned or melted away without melting the platinum . Finally , platinum is resistant to hydrochloric and sulfuric acids , whereas other substances are readily attacked by them . Metal impurities can be removed by stirring the mixture in either of the two acids and recovering the remaining platinum .

One suitable method for purification for the raw platinum , which contains platinum , gold , and the other platinum @-@ group metals , is to process it with aqua regia , in which palladium , gold and platinum are dissolved , whereas osmium , iridium , ruthenium and rhodium stay unreacted . The gold is precipitated by the addition of iron (II) chloride and after filtering off the gold , the platinum is precipitated as ammonium chloroplatinate by the addition of ammonium chloride . Ammonium chloroplatinate can be converted to platinum by heating . Unprecipitated hexachloroplatinate (IV) may be reduced with elemental zinc , and a similar method is suitable for small scale recovery of platinum from laboratory residues .

= = Applications = =

Of the 218 tonnes of platinum sold in 2014 , 98 tonnes were used for vehicle emissions control devices (45 %) , 74 @.@ 7 tonnes for jewelry (34 %) , 20 @.@ 0 tonnes for chemical production and petroleum refining (9 @.@ 2 %) , and 5 @.@ 85 tonnes for electrical applications such as hard disk drives (2 @.@ 7 %) . The remaining 28 @.@ 9 tonnes went to various other minor applications , such as medicine and biomedicine , glassmaking equipment , investment , electrodes , anticancer drugs , oxygen sensors , spark plugs and turbine engines .

= = = Catalyst = = =

The most common use of platinum is as a catalyst in chemical reactions , often as platinum black . It has been employed as a catalyst since the early 19th century , when platinum powder was used to catalyze the ignition of hydrogen . Its most important application is in automobiles as a catalytic converter , which allows the complete combustion of low concentrations of unburned hydrocarbons from the exhaust into carbon dioxide and water vapor . Platinum is also used in the petroleum

industry as a catalyst in a number of separate processes , but especially in catalytic reforming of straight @-@ run naphthas into higher @-@ octane gasoline that becomes rich in aromatic compounds . PtO2 , also known as Adams ' catalyst , is used as a hydrogenation catalyst , specifically for vegetable oils . Platinum also strongly catalyzes the decomposition of hydrogen peroxide into water and oxygen and it is used in fuel cells as a catalyst for the reduction of oxygen .

= = = Standard = = =

From 1889 to 1960 , the meter was defined as the length of a platinum @-@ iridium (90 : 10) alloy bar , known as the International Prototype Meter bar . The previous bar was made of platinum in 1799 . The International Prototype Kilogram remains defined by a cylinder of the same platinum @-@ iridium alloy made in 1879 .

The standard hydrogen electrode also uses a platinized platinum electrode due to its corrosion resistance , and other attributes .

= = = As an investment = = =

Platinum is a precious metal commodity ; its bullion has the ISO currency code of XPT . Coins , bars , and ingots are traded or collected . Platinum finds use in jewellery , usually as a 90 ? 95 % alloy , due to its inertness . It is used for this purpose for its prestige and inherent bullion value . Jewellery trade publications advise jewellers to present minute surface scratches (which they term patina) as a desirable feature in attempt to enhance value of platinum products .

In watchmaking , Vacheron Constantin , Patek Philippe , Rolex , Breitling , and other companies use platinum for producing their limited edition watch series . Watchmakers appreciate the unique properties of platinum , as it neither tarnishes nor wears out (the latter quality relative to gold) .

The price of platinum , like other industrial commodities , is more volatile than that of gold . In 2008 , the price of platinum dropped from $ 2 @,@ 252 to $ 774 per oz , a loss of nearly 2 / 3 of its value . By contrast , the price of gold dropped from ~ $ 1 @,@ 000 to ~ $ 700 / oz during the same time frame , a loss of only 1 / 3 of its value .

During periods of sustained economic stability and growth , the price of platinum tends to be as much as twice the price of gold , whereas during periods of economic uncertainty , the price of platinum tends to decrease due to reduced industrial demand , falling below the price of gold . Gold prices are more stable in slow economic times , as gold is considered a safe haven . Although gold is used in industrial applications , its demand is not so driven by industrial uses . In the 18th century , platinum 's rarity made King Louis XV of France declare it the only metal fit for a king .

= = = Other uses = = =

In the laboratory , platinum wire is used for electrodes ; platinum pans and supports are used in thermogravimetric analysis because of the stringent requirements of chemical inertness upon heating to high temperatures (~ 1000 ° C) . Platinum is used as an alloying agent for various metal products , including fine wires , noncorrosive laboratory containers , medical instruments , dental prostheses , electrical contacts , and thermocouples . Platinum @-@ cobalt , an alloy of roughly three parts platinum and one part cobalt , is used to make relatively strong permanent magnets . Platinum @-@ based anodes are used in ships , pipelines , and steel piers .

= = = Symbol of prestige = = =

Platinum 's rarity as a metal has caused advertisers to associate it with exclusivity and wealth . " Platinum " debit and credit cards have greater privileges than " gold " cards . " Platinum awards " are the second highest possible , ranking above " gold " , " silver " and " bronze " , but below diamond . For example , in the United States , a musical album that has sold more than 1 million copies , will be credited as " platinum " , whereas an album that sold more than 10 million copies will be certified

as " diamond " . Some products , such as blenders and vehicles , with a silvery @-@ white color are identified as " platinum " . Platinum is considered a precious metal , although its use is not as common as the use of gold or silver . The frame of the Crown of Queen Elizabeth The Queen Mother , manufactured for her coronation as Consort of King George VI , is made of platinum . It was the first British crown to be made of this particular metal .

= = Health issues = =

According to the Centers for Disease Control and Prevention , short @-@ term exposure to platinum salts may cause irritation of the eyes , nose , and throat , and long @-@ term exposure may cause both respiratory and skin allergies . The current OSHA standard is 2 micrograms per cubic meter of air averaged over an 8 @-@ hour work shift . The National Institute for Occupational Safety and Health has set a recommended exposure limit (REL) for platinum as 1 mg / m3 over an 8 @-@ hour workday .

Platinum @-@ based antineoplastic agents are used in chemotherapy , and show good activity against some tumors .

As platinum is a catalyst in the manufacture of the silicone rubber and gel components of several types of medical implants (breast implants , joint replacement prosthetics , artificial lumbar discs , vascular access ports , etc .) , the possibility that platinum could enter the body and cause adverse effects has merited study . The Food and Drug Administration and other institutions have reviewed the issue and found no evidence to suggest toxicity in vivo .