



UGUSSA

PLATINUM EQUIPMENT
Resistance and handling

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Correct handling of platinum equipment

Advantages of platinum equipment

Platinum is one of the most resistant metals. Above all other metals, it is suitable for chemical laboratory equipment because of its resistance to chemical corrosion, its high melting point (1768 °C) and its low vapour pressure.

Its acid resistance, particularly its complete resistance to hydrofluoric acid alone and in mixtures with sulphuric acid and/or nitric acid, together with its annealing resistance which is manifest as constant weight even for strongly annealed equipment and is extremely valuable in practice, is not achieved by any other metallic material. Its unique catalytic efficiency facilitates the ashing of organic materials, especially filter substances.

Finally, a particularly valuable asset is that platinum can be processed with no problems in any respect so that there are hardly any restrictions on its forming. Another particular advantage is that it can be homogeneously welded without any defects so that soldering which generally represents areas of low chemical and thermal resistance can be completely avoided.

Quality of platinum equipment

Quite understandably, the good properties of platinum equipment described above are only achieved for platinum which is completely perfect in every respect. The degree of purity of the starting material and complete homogeneity are the most important requirements: but in order to produce satisfactory equipment in every respect the processing must be suited to the material, as can only be ensured by dealing with platinum materials over many decades.

Pure platinum is very soft and loses the work hardness achieved during its processing into equipment when annealed at 700-1000 °C, which is a disadvantage when using laboratory equipment. It is therefore hardened by small admixtures of other precious metals such as iridium, rhodium or gold, with its resistance to chemical corrosion remaining the same or in some cases even being improved.

The materials listed in **Table 1** are available for various applications:

Table 1: Precious metal materials for laboratory equipment having various functions

Material	Equipment	Applications
Pt/Ir 97/3%	Crucibles, dishes	Normal analytical operations, e.g.: acid or alkaline decompositions, vaporisation of HF, annealing of filter residues
	Gooch or Neubauer filter crucibles	Filtration of aggressive liquids followed by drying or annealing the residue
Pt/Ir 95/5% Pt/Ir 90/10% Pt/Ir 75/25%	Electrodes capillary tubes, spatula capillary tubes	Electro-analytical determination of metals such as Ag, Cu, Zn, Cd, Pb
Pt/Au 95/5	Crucibles and dishes	Normal analytical operations, but especially coking and melting of samples for XRF
	Crucibles and solids of rotation	Rotary viscosimeters for glass melts, also made of Pt/Rh 90/10% and Pt/Rh 80/20%
Pt/Rh 90/10%	Crucibles	Decompositions at high temperatures in ceramics, cement and metallurgical laboratories. If Rh_2O_3 formed during alkaline decompositions has a disturbing effect, inner plating with Pt/Ir 97/3% may be used
Pt/Rh 80/20%	Dishes	Decompositions of ferrophosphorus and ferrosilicon
Au/Pt 90/10%	Dishes	Flour ashing
Pt/Pd 80/20	Dishes	Flour ashing
Rh or Ir	Crucibles	Growth of oxide single crystals

Limits of applicability

The numerous good properties of the material can easily make us forget that in certain cases, extremely resistant platinum can be very reactive. It is strongly corroded by a few reagents and in some cases, completely destroyed.

General remarks on substances having a harmful effect

The substances harmful to platinum equipment are given more or less completely in most handbooks of inorganic and particularly analytical chemistry. The main ones are free chlorine, chlorine from hydrochloric acid - nitric acid mixtures (aqua regia), hydrochloric acid with other oxidising agents, such as chromic acid, manganates or iron(III) salts, as well as certain molten salts which chemically dissolve platinum; also the low-melting metals such as lead, tin, zinc, silver, aluminium, mercury, alkali metals, antimony, bismuth, either primary or secondary as formed by reduction from compounds, elemental phosphorus, arsenic, boron and silicon which alloy with platinum, substantially reducing its melting point.

There is no need to indicate that the harmfulness of these various substances exhibits considerable differences in degree. In some cases a few hundredths of a milligram can make an item of platinum equipment completely unusable whereas other harmful substances can come in contact with the equipment for long periods without substantially reducing its usability. However, little detailed information can be found on this topic which is all the more unfortunate since the use of platinum equipment offers major advantages when working with some inherently harmful substances. Thus, in the following we shall give an overview of the most important substances having a harmful influence on platinum, taking into account the severity of its influence on platinum. We hope that our discussions will contribute towards the

knowledge of platinum equipment which will not only save the user of the equipment from quite considerable trouble but will also bring about a longer lifetime and, under certain circumstances, extend the area of application.

Substances having a destructive effect

Apart from the purely chemical dissolving effect of atomic chlorine in liquids, such as from hydrochloric acid - nitric acid mixtures, and from some molten salts, any marked destruction of platinum equipment can most probably be attributed to alloying of platinum with other metals or metalloids. These alloys mostly have a much lower melting point than platinum which is exceeded at the normal working temperatures; holes or cracks are then formed in the equipment as a result of local melting.

Formation of alloys with metals

Of particular importance in relation to harmfulness are the low-melting metals such as lead, tin, antimony or bismuth which even in low concentrations, substantially lower the melting point of platinum, result in the formation of holes in equipment. In this case, it is not necessary for the metals as such to be introduced into the equipment. Attempts to heat these metals in platinum equipment are probably only made in very rare cases but it is occasionally overlooked that some of their compounds, namely their oxides, can very easily be reduced to the metal, for example by filter charcoals. It occasionally also happens that traces of light-melting metal, predominantly tiny soft solder particles, reach the platinum equipment **from outside**, become attached to it and form holes when the equipment is next heated.

The reasoning that has been put forward for the light-melting metals (including mercury) and compounds also applies in principle to the higher-melting metals if the heating is extended into the vicinity of their melting point, which should basically be avoided in contact with platinum equipment.

If during the formation of an alloy with a higher-melting metal, such as iron, the melting point is not reduced to such an extent that it directly results in destruction of the equipment, the general corrosion resistance of the equipment is substantially reduced by this alloy formation and the material becomes embrittled so that secondary influences can bring about complete destruction. A platinum-iron alloy is formed for example if an item of platinum equipment is heated to temperatures above 1200 °C in the presence of iron oxide.

Apart from free carbon, where reference is again made to the filter charcoal, possible reducing agents for metal oxides include all organic compounds, e.g. metal salts of organic acids. Reducing flame gases from the heating sources have a similar effect. It should be noted in particular that hydrogen is first occluded from platinum starting at 400 °C and at higher temperatures diffuses through the equipment walls. Contrary to incorrect information given in the literature, hydrogen by itself should not be considered as a harmful substance, only its effect on reducible compounds in the annealed material is hazardous.

Formation of alloys with metalloids

Like metals, the metalloids also form low-melting alloys with platinum, which is frequently not yet taken sufficiently into account. Particular mention may be made of silicon, phosphorus and arsenic for which information on their effect as harmful substances is available in the more recent literature and to which particular attention should be paid on account of their topochemically specific corrosion. Whereas the formation of a platinum-tin alloy extends approximately over the entire surface, the formation of alloys with phosphorus and arsenic extends preferentially along the grain boundaries where it progresses rapidly and very quickly results in cracking (Fig. 1).

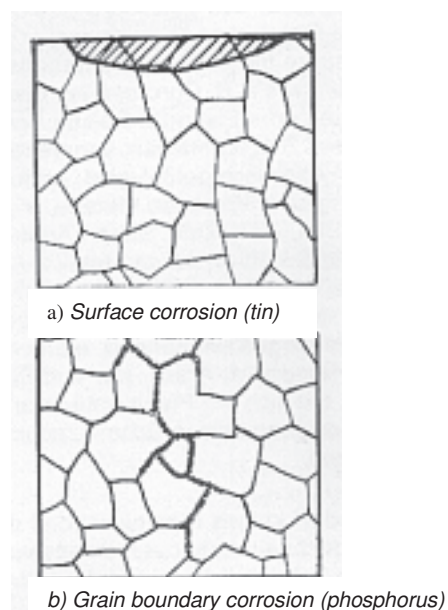


Fig. 1: Topochemical differences between corrosion of platinum

a) Surface corrosion (tin)

b) Grain boundary corrosion (phosphorus)
(from J. Fischer)

Silicon forms the silicide Pt_3Si , drastically reducing the platinum melting point, which for its part forms a eutectic with platinum that melts at 830 °C.

The formation of alloys in the presence of free silicon, if appropriately formed by reduction of primary silicon dioxide by carbon or water (in very small quantities), results in perforation of the crucible wall via the low melting eutectic $\text{Pt-Pt}_3\text{Si}$.

Phosphorus reacts in a similar way. It combines in fractions of a milligram with the platinum to form the platinum phosphide Pt_{20}P_7 , which forms a particularly low-melting (588 °C) eutectic with platinum $\text{Pt-Pt}_{20}\text{P}_7$. The melting point of the platinum infected with phosphorus immediately drops locally to around 600 °C (eutectic melt), with cracks and holes being unavoidable. This process is particularly hazardous during ashing of organic substances, such as flour, however small the specific phosphorus content may be. In such cases, care must be taken to ensure that the operations are carried out at the lowest possible temperature and with sufficient air intake.

If a certain amount of phosphorus uptake by the platinum cannot be avoided, it is recommended that equipment made of platinum/rhodium alloys (e.g. containing 20% Rh) should be used or equipment made of pure rhodium whose alloys with phosphorus only melt at substantially higher temperatures than the eutectic Pt-Pt₂₀P₇.

The alloy Au/Pt 90/10% has proved suitable for the ashing of phosphorus-containing organic substances (cereals and flour). Since this begins to melt just above 1100 °C, the usage temperature of such equipment is restricted to a maximum of 950 °C.

Arsenic and platinum also form a low-melting eutectic (597 °C), which, as has been known for a long time, even made possible the first method for producing workable platinum (Achard, 1779). In the same way as for phosphorus, platinum arsenides can be formed by annealing arsenic-containing compounds, e.g., Mg₂As₂O₇, in the presence of reducing substances (flame gases or filter charcoal). The same measures as for phosphorus corrosion are recommended to limit arsenic corrosion.

Harmful substances

Whereas the harmfulness of the substances mentioned above is generally underestimated, the damage to platinum equipment by the following substances is generally lower than is commonly assumed.

For example, platinum dissolves only slowly in aqua regia in the cold and even at water bath temperature a crucible takes a number of hours to dissolve.

Alkali hydroxides, carbonates, sulphides, cyanide and thiocyanates certainly corrode the platinum to some extent at higher temperatures (see Table 3) but frequently the use of platinum equipment offers so many advantages that a certain loss of substance

can be accepted. During melting with caustic alkalis or alkali carbonates the corrosion can be limited substantially by adding alkali nitrate (for caustic alkalis twice the quantity of nitrate, for carbonates half the quantity of nitrate) and adhering to an upper temperature limit of 700 or 550 °C. For sodium peroxide and cyanide melts the critical temperature is 500 °C, for carbonates and neutral salts it is around 800 °C. In all these cases it is recommended that contrary to the operating method during annealing or ashing, the crucible should always be covered since less corrosion occurs when the air intake is reduced. Platinum equipment, like other crucible materials, is generally more corroded by potassium salts than by the corresponding sodium salts.

In the case of glasses and ceramics it should be checked whether metallic components (e.g. lead, antimony, arsenic, iron and others) can be formed by secondary reduction processes from heavy metal oxides. Platinum is not corroded by magnesium silicates (asbestos) in an oxidising atmosphere up to 1400 °C whereas in a weakly reducing atmosphere melting to form a slag mass of unknown composition occurs at red heat.

As a result of the action of carbon or reducing flame gases (from luminous gas flames or from the interior cone of a gas flame) on empty platinum equipment, the surface becomes roughened. This roughening can only be partly eliminated by strongly annealing the equipment in an oxidising atmosphere. Thus, the original smoothness of the surface is not fully restored. This damage to the platinum by carbon and reducing flame gases is only minor and not of a far-reaching nature as long as no reducible compounds of the platinum poisons mentioned above e.g. metal oxides, are present. Otherwise the platinum forms alloys with the elements released as a result of the reduction. Platinum equipment is only damaged by sulphur and sulphur-containing gases above 1550 °C.

Treatment of platinum equipment

Heating

Annealing and ashing in platinum equipment should basically be carried out in an oxidising atmosphere, i.e., in an open crucible with unhindered air intake, in order to avoid any reduction of metals or metalloid compounds which may be present, e.g. by filter charcoal. It is advisable to initially preheat the material to be annealed at a lower temperature until all the organic substances have been burnt. Experience shows that it is only more advantageous to work with covered crucibles to impede oxygen from the air from reaching the crucible contents in the case of decomposition melts with alkali salt mixtures.

Platinum equipment is heated most gently in an electric crucible furnace or in a muffle furnace. During annealing over a burner or a blowpipe the inner cone of the flame must not come in contact with the crucible otherwise hydrogen can be absorbed which has a reducing action on the crucible contents.

Unnecessarily long heating of platinum equipment to high temperatures should be avoided since this can lead to coarsening of the crystal structure, embrittlement and cracking.

Red-hot platinum equipment should not come in contact with foreign metals. During annealing in electrical furnaces care should be taken to ensure that the ceramic material on which the crucible is placed is scrupulously clean; this also applies to the base plates on which the platinum equipment is left to cool after the annealing has ended. When heating over burners or blowpipes, the platinum equipment must not be brought in direct contact with iron triangles or wire meshes but triangles either having three spacer points made of platinum-iridium or having tubes made of a suitable ceramic material must be used.

Triangles made of heat-resistant steel wire and quartz tubes are very durable.

When working on water baths avoid using metal rings and use the most suitable porcelain rings. Tongs and pincers used to handle the red-hot equipment must not be made of iron or brass. Tongs or pincers with platinum tips or shoes are the most suitable.

When several new items of platinum equipment are annealed at the same time in a muffle furnace, it should be borne in mind that polished walls or crucible edges and lids coming in contact may become welded together as a result of self-diffusion even at red heat, i.e., they may stick together. This tendency diminishes as the equipment is increasingly used.

Cleaning and care

Platinum equipment naturally needs to be carefully looked after and cleaned after use. After boiling with suitable solvent in each case, it is recommended that equipment should occasionally be rubbed with sea sand which improves its appearance and lifetime quite considerably. Abrasion using round grains of sand not only removes alloys formed on the surface but also polishes the surface at the same time and makes it more resistant to corrosion.

Vigorous cleaning is achieved by melting potassium hydrogen sulphate or potassium disulphate in the crucibles and dishes. It is incorrect to continue to burn off impurities by vigorous annealing from the platinum. Only in a very few cases does this method have the desired effect but it is always better to remove any impurities mechanically or chemically before annealing the platinum equipment.

Frequently used platinum equipment can easily become kinked, which soon results in the walls having a folded appearance.

This folding not only makes it difficult to clean the crucible and remove any melt cake but also reduces the lifetime of the equipment. It is thus advisable to keep the crucible walls permanently smooth. This can easily be achieved by using a wood or plastic mould or more easily by rolling the crucible on a flat surface whilst simultaneously pressing a round wooden rod of approximately pencil thickness onto the inner wall. It is much too easily forgotten that in many cases mechanical deformations contribute towards premature wear of the equipment, which far exceeds the slight chemical corrosion. Thus, from the very beginning the wall thicknesses of the crucible and dishes should not be chosen to be too thin in order to avoid any bending and twisting when held with the crucible tongs. Naturally the jaws of the crucible tongs should be provided with platinum shoes which are not too short.

Various tricks can be used to dissolve barely soluble disulphate and sodium carbonate melts (decomposed substances) from platinum crucible. It is especially convenient as proposed by **H. and W. Biltz** to allow a thick platinum wire to "freeze in" the melt cake shortly before solidification and suspend this in the dissolving liquid by bending it twice together with the platinum crucible (see Fig. 2). The heavy salt solution formed in the crucible sinks to the bottom and is automatically replaced by fresh solvent. Fast quantitative dissolution is achieved by means of this circulating process with very careful treatment of the crucible material.

It may be mentioned that the material Pt/Au 95/5% among others has the feature that it is poorly wetted by many glasses and molten salts. In such cases, melt cakes can easily be removed by simply slipping from these crucibles after cooling.

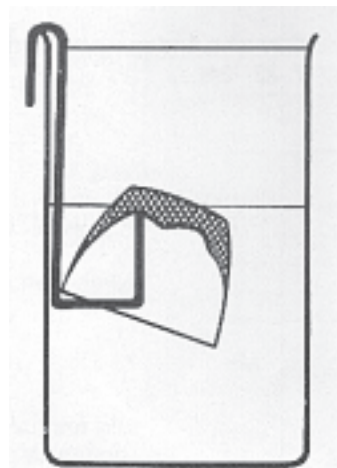


Figure 2: Dissolving out solidified melt from a platinum crucible (from H. and W. Biltz (18))

Contrary to other information given in the literature, metal deposits can be dissolved from **electrodes** after the end of electrolytic determinations using highly concentrated, analytically pure acids, provided that slight corrosion is allowed (<0.1 mg). Zinc deposited electrolytically on bare platinum electrodes which have not been previously copper plated may be dissolved using concentrated nitric acid as a result of partial surface alloying since hydrochloric acid dissolves the platinum with it and sulphuric acid does not quantitatively remove the zinc.

The annealing of wire-gauze electrodes in a naked flame is not recommended since metal traces adhering in a dead corner can burn, undesirable coarse grain formation is promoted and mechanical deformations ultimately take place under the heat as a result of the electrodes' own weight. The wire gauze covering can then certainly be expected to tear. After rinsing with distilled water and alcohol, the electrodes should then be dried between 100 and 150 °C in a drying cupboard and preferably kept, standing in a beaker in a desiccator.

Lifetime of platinum equipment

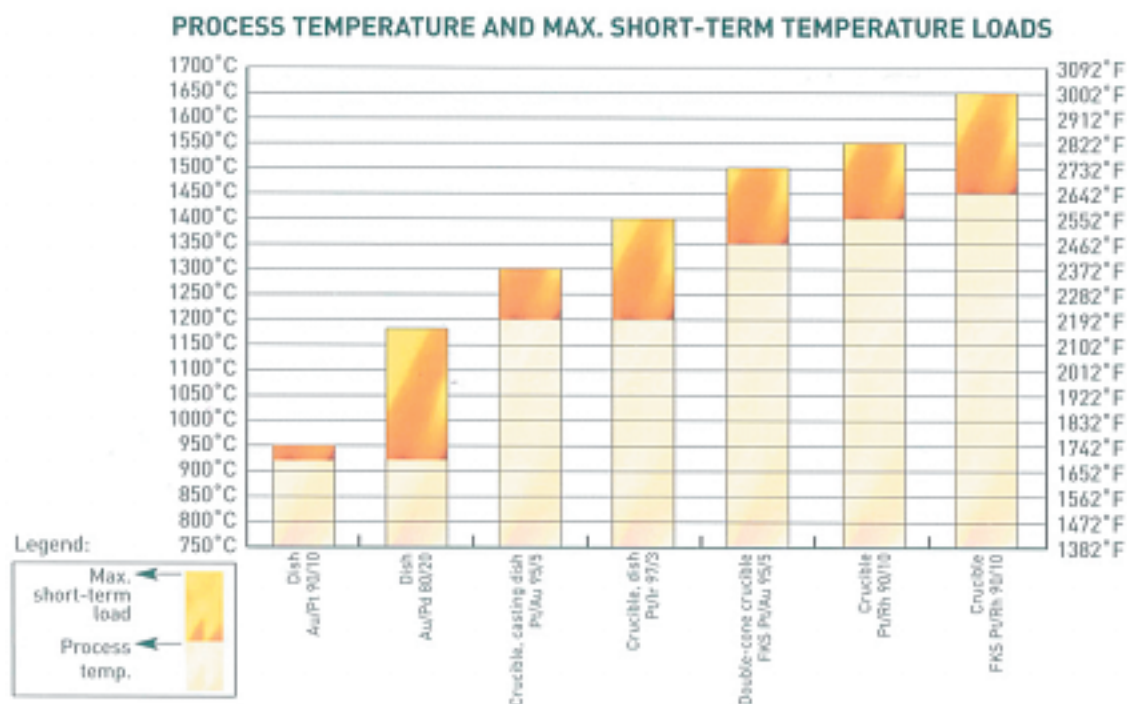
Although premature destruction of platinum equipment can be reliably avoided by taking into account the previous reasoning and being attentive, an unlimited shelf life cannot be ensured. Their lifetime is substantially longer than that of most other laboratory equipment but highly stressed crucibles such as coking crucibles become brittle and unsightly after a large number of determinations. For crucibles, dishes and laboratory electrodes an average

number of 1000 operations may be assumed. Reworking the equipment after suitable operating times is to be recommended in any case.

Should difficulties arise when dealing with platinum equipment or special problems need to be solved, our research laboratories will be pleased to collaborate with you.

The maximum permissible temperatures up to which melts can be handled in platinum crucibles you can see in the next chart.

A quantitative overview of the resistance of platinum group metals to commonly used chemical reagents and the physical data are in the following charts.



RESISTANCE TO CORROSIVE MEDIA OF PLATINUM GROUP METALS, GOLD AND SILVER

Corrosive medium	Conditions	[°C]	[°F]	Pd	Pt	Rh	Ir	Ru	Os	Au	Ag
Hydrochloric acid	36%	20	68	1	1	1	1	1	1	1	1
Hydrochloric acid	36%	100	212	2	1	1	1	1	3	1	2
Nitric acid	65%	20	68	4	1	1	1	1	3	1	4
Nitric acid	65%	100	212	4	1	1	1	1	4	1	4
Sulphuric acid	96%	20	68	1	1	1	1	1	1	1	2
Sulphuric acid	96%	100	212	3	1	2	1	1	1	1	4
Sulphuric acid	96%	300	572		2	3			1	3	4
Hydrobromic acid	60%	20	68	4	2	2	1	1	1		3
Hydrobromic acid	60%	100	212	4	4	3	1	1	3	1	4
Hydriotic acid	57%	20	68	4	1	1	1	1	2	1	4
Hydriotic acid	57%	100	212	4	4	1	1	1	3	1	4
Fluorohydric acid	40%	20	68	1	1	1	1	1	1	1	1
Phosphoric acid		100	212	2	2	1	1	1	4	1	1
Acetic acid	99%	100	212	1	1	1	1	1		1	1
Hydrochloric acid/chlorine	20%/saturated	20	68	3	2					4	4
Hydrochloric acid/chlorine	20%/saturated	80	176	4	4					4	4
Hydrochloric acid/chlorine	20%/saturated	100	212	3	3	2	2			4	4
Hydrochloric acid/bromine		20	68	4	2	2					4
Hydrochloric acid/bromine		100	212	4	2						4
Aqua regia		20	68	4	4	1	1		4	4	4
Aqua regia		100	212	4	4	1	1		4	4	4
Aqua regia		150	302	4	4		3			4	4
Hydrochloric acid/H ₂ O ₂		20	68	4						4	4
Hydrochloric acid/H ₂ O ₂		100	212	4	2					4	4
Hydrobromic acid/bromine	60%	100	212			4					
Water/bromine		20	68	2	1	1	1	1	1	4	2
Ethanol/Iodine		20	68	2	1	2	1	1		3	4
Sodium hypochloride solution		20	68	3	1	2		4	4	1	1
Sodium hypochloride solution		100	212	4	1	2	2	4	4	1	2
Potassium cyanide solution		20	68	3	1					4	4
Potassium cyanide solution		100	212	4	3					4	4
Copper(II) chloride solution		100	212	2	1					1	
NaOH melt	air access	500	932	2	2	2		4	4	2	2
KOH melt	air access	500	932	2	3	2		4	4	4	3
NaOH melt	air access	800	1472	3		2		4	4	4	4
KOH melt	air access	800	1472	3		2		4	4	4	4
KHSO ₄ melt	air access	440	824	2	1	3	1			2	4
NaCN melt	air access	700	1292	3	3	4	3	3		4	4
KCN melt	air access	700	1292	4	4	3	3	3		4	4
NaCN/KCN melt (2:1)	air access	550	1022	3	3	4	3	3		4	4
Chlorine, gaseous	dry	20	68	3	2	1	1	1	1	3	1
Chlorine, gaseous	moist	20	68	4	2	1	1	1	3	4	2
Bromine liquid	dry	20	68	4	3	1	1	1	4	4	1
Bromine liquid	moist	20	68	4	3	1	1	1	3	4	1
Iodine solid	dry	20	68	1	1	1	1	1	2		
Iodine solid	moist	20	68	2	1	2	1	1	1		4
Fluorine gaseous		20	68		2					1	1
Hydrogen sulphide gaseous	moist	20	68	1	1	1	1	1	1	1	

1 = no corrosion
 2 = marginal corrosion
 3 = strong corrosion
 4 = destructive corrosion

These values in this table are only for reference purposes and should not be used for specific applications.

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INFLUENCE OF PLATINUM-DAMAGING SUBSTANCES ON THE MELTING TEMPERATURE

Element	Pt		Pd		Au		Ag		Rh		Ir	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
B	825	1517	743	1369	1050	1922	961	1762	1131	2068	1046	1915
Si	830	1526	798	1468	370	698	835	1535	1389	2532	1470	2678
P	588	1090	788	1450	935	1715	878	1612	1245	2273	1262	2304
As	597	1107	-	-	685	1229	540	1004	-	-	-	-
Sn	1070	1958	-	-	278	532,4	221	429,8	-	-	-	-
Sb	633	1171	590	1094	360	680	485	905	610	1130	-	-
Pb	290	554	265	509	213	415,4	304	579,2	-	-	-	-
Bi	730	1346	-	-	241	465,8	262	503,6	-	-	-	-
S	1240	2264	623	1153	-	0	742	1368	925	1697	-	-

PHYSICAL DATA OF PRECIOUS METALS AND PRECIOUS METAL ALLOYS

Material	Melting point, melting interval		Density (g/cm³)	Coefficient of linear expansion (20-100°C) 10⁻⁴ (K⁻¹) [68-212°F] 10⁻⁴ (K⁻¹)	Specific, electrical resistance [annealed] at 20° C [0°mm²·m⁻¹] 68° F [0°mm²·m⁻¹]	Temperature coefficient of the specific electr. resistance [0-100°C] 10⁻⁴ (K⁻¹) [32-212°F] 10⁻⁴ (K⁻¹)
	°C	°F				
Pt	1769	3216,2	21,45	9,1	0,107	39,0
Ir	2447	4436,6	22,65	6,8	0,049	43,0
Pd	1554	2829,2	12,02	11,1	0,099	38,0
Rh	1963	3565,4	12,41	8,3	0,043	46,0
Os	3050	5522,0	22,61	6,1	0,096	42,0
Ru	2315	4199,0	12,20	9,1	0,073	46,0
Au	1063	1945,4	19,32	14,1	0,027	40,0
Ag	961	1761,8	10,49	18,7	0,016	41,0
PtRh 10	1840-1870	3344-3398	20,00	10,0	0,200	16,3
PtRh 20	1870-1910	3398-3470	18,10	9,3	0,208	13,4
PtIr 10	1780-1800	3236-3272	21,60	8,6	0,250	12,0
PtIr 20	1830-1855	3326-3371	21,70	7,7	0,310	7,5
PtAu 5	1675-1745	3047-3173	21,32	-	0,180	21,0
FKS-Pt*	1769	3216,2	21,45	-	-	-
FKS-PtAu5*	1675-1745	3047-3173	21,32	-	-	-
FKS-PtRh10*	1840-1870	3344-3398	20,00	-	-	-

Material	Thermal conductivity at 20°C (Wm⁻¹K⁻¹) 68°F (Wm⁻¹K⁻¹)	Yield point (MPa)		Tensile strength (MPa)		Elongation at break (%)		Vickers hardness		Elasticity module (GPa)
		annealed	hard	annealed	hard	annealed	hard	annealed	hard	
Pt	74	70	290	150	330	40	3,0	42	98	170
Ir	59	93	-	450	-	7	-	210	453	528
Pd	75	65	400	180	480	35	3,0	40	210	121
Rh	88	68	-	800	1925	9	-	130	410	380
Os	87	-	-	-	-	-	-	350	1000	570
Ru	105	38	-	500	-	3	-	240	750	430
Au	312	50	260	180	300	40	3,0	40	90	78
Ag	419	120	320	140	380	37	3,0	35	110	80
PtRh 10	30	180	670	300	680	32	1,5	102	204	255
PtRh 20	-	110	920	380	940	32	2,0	113	273	268
PtIr 10	31	220	630	340	650	32	2,0	105	215	220
PtIr 20	-	380	920	570	940	21	2,0	190	300	230
PtAu 5	-	370	610	460	635	7	1,0	139	194	180
FKS-Pt*	-	180	-	265	-	25	-	85	-	-
FKS-PtAu5*	-	260	-	390	-	19	-	115	-	-
FKS-PtRh10*	-	330	-	445	-	16	-	115	-	-


Addition physical data can be found in the Landolt-Börnstein Comprehensive Index, 1996, Volume IV, Part 2, Springer-Verlag

* Test compliant with Ögussa-Standard, 2001.



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THE WORLD OF PRECIOUS METALS