MODERN DICTIONARY

Inorganic
Chemistry

G Kano

A

Acid rain. Man's impact on atmospheric chemistry is steadily increasing with progressive industrialization and urbanization. In the last few decades precipitation in serveral areas of the world has become increasingly more acidic. The term Acid rain is used to describe all precipitation rain, snow, sleet, etc. that has a pH less than 5.6, the pH expected in pure rain.

Acid rain is produced due to increase in sulphuric acid and nitric acid aerosols by fossil fuel combustion, metal smelting and industrial processes. Sulphur dioxide and nitrogen oxides are the two main culprits responsible for the acidic precipitation problem.

The study of precipitation chemistry is a relatively new field and the understanding of the phenomenon is limited. However, on the basis of available information, ecological effects of acid rain are far reaching, insidious often irrevesible and operating slowly in complex ways. In regious where acid neutralizing capacity of soils and water is low, the pH of streams and lakes have decreased and the metal concentration has increased. Aquatic organism have been affected at all tropic levels, abundance, production and growth have reduced and sensitive species have been lost. Other effects include changes in nutrient budgets of forest, agricultural lands, loss of soil fertility and decrease in the crop and forest productivity, corrosion and deterioration of materials. In the coming years due to the escalating rate of energy demand and industrialization, acid precipitation problems are likely to intensify.

Acid salt (acidic salt). It is a salt in which there is only partial replacement of the acidic hydrogen of an acid by metal or other cations. For polybasic acids the formulae are of the type $NaHSO_4$ (sodium hydrogensulphate) and $Na_3H(CO_3)_2$. $2H_2O$ (sodium sesquicarbonate). For monobasic acids such as

HF the acid salts are of the type KHF_2 (potassium hydrogen fluoride).

Acids and bases. The word acid comes from a Latin word *acidus* meaning sour, since a sour taste was one of the earliest recognised properties of this class of substances.

Arrhenius Definition As early as 1867 Arhenius defined an acid to be a substance which dissociates to yield hydrogon ion in aqueous solution. Similarly, an aqueous solution of a base gives hydroxyl ion in solution.

Thus,

$$HCl(aq) \rightleftharpoons H^+(aq) + Cl^-$$
$$\text{acid}$$

$$NaOH(aq) \rightleftharpoons Na^+(aq) + OH^-(aq)$$
$$\text{base}$$
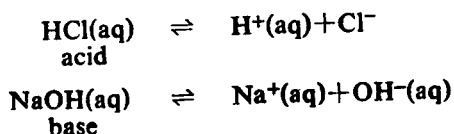
This definition is of limited application and is valid only in aqueous solution. It does not cover other substances that do not contain H^+ and OH^- ions but can neutralize bases and acids respectively.
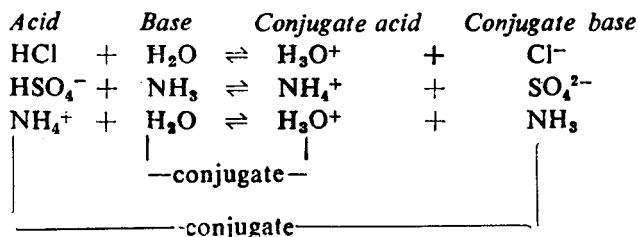
Bronsted-Lowry concept In 1923, a more general concept of acids and bases was introduced independently by J.N. Bronsted of Denmark and T.M. Lowry of England. According to Bronsted-Lowry definition, an acid is a substance that gives up a proton and a base is a substance that accepts a proton.
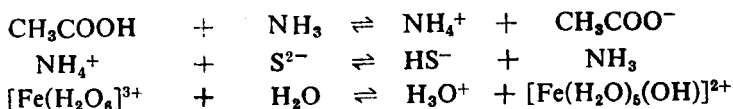
In a typical acid-base reaction,

$$HX + B \rightleftharpoons X^- + HB^+$$
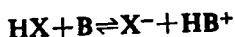
HX being a proton donor is an acid and B being a proton acceptor is a base in the forward reactions. In the back reaction HB^+ being a proton donor is an acid and X^- being a proton acceptor is a base. To make a distinction between the two acids and two bases, those on the right-hand side of the equation are referred to as the conjugate acid and the conjugate base. Thus HB^+ is a conjugate acid of the base B and X^- is a conjugate base of acid HX. HX—X^- and HB^+—B constitute two conjugate acid-base pairs. The acid and base in each conjugate
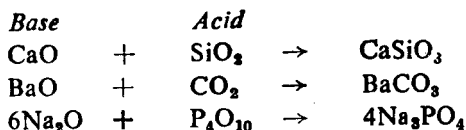
differ by a proton, In order that an acid may exhibit its acidic properties there must be a proton acceptor (base) present. Some examples are:

Acid		Base		Conjugate acid		Conjugate base
HCl	+	H_2O	$\rightleftharpoons$	H_3O^+	+	Cl^-
HSO_4^-	+	NH_3	$\rightleftharpoons$	NH_4^+	+	SO_4^{2-}
NH_4^+	+	H_2O	$\rightleftharpoons$	H_3O^+	+	NH_3

—conjugate—

————conjugate————

Thus, according to this concept neutralization is a process of transfer of a proton from an acid to a base. Some more examples may be cited as:

$$CH_3COOH \quad + \quad NH_3 \quad \rightleftharpoons \quad NH_4^+ \quad + \quad CH_3COO^-$$
$$NH_4^+ \quad + \quad S^{2-} \quad \rightleftharpoons \quad HS^- \quad + \quad NH_3$$
$$[Fe(H_2O_6)]^{3+} \quad + \quad H_2O \quad \rightleftharpoons \quad H_3O^+ + [Fe(H_2O)_5(OH)]^{2+}$$

Lux Flood concept The proton plays a vital role in explaining the acid-base behaviour in the Bronsted-Lowry concept. It was observed by Lux (1939) that the acid-base reactions are also feasible in oxide systems without the aid of protons. This approach was extended by Flood (1947) and applied to non-protonic systems which were not covered by the Bronsted-Lowry concept. According to the Lux·Flood definition, a base (like CaO, BaO or Na_2O) is an oxide ion donor and an acid (like SiO_2, CO_2 or P_4O_{10}) is an oxide ion acceptor. Some acid-base reactions, in terms of the Lux-Flood concept may be written as:

Base		Acid		
CaO	+	SiO_2	$\rightarrow$	$CaSiO_3$
BaO	+	CO_2	$\rightarrow$	$BaCO_3$
$6Na_2O$	+	P_4O_{10}	$\rightarrow$	$4Na_3PO_4$

The concept is particularly applicable to reactions which take place at high temperature, i.e. in metallurgical operations or during the manufacture of ceramics and glass. The approach can be extended to include other negative ion systems (like halides, sulphide or carbanions),

Cady Elsey concept The Arrhenius theory of acids and bases in aqueous solution was extended to liquid ammonia solvent system by Cady and Elsey. According to this theory, water ionizes as:

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

Similarly, liquid ammonia ionizes and produces ammonium ion, NH_4^+ and amide ion NH_2^-.

$$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$

According to Cady-Elsey concept, any substance that can produce the cation characteristics of ammonia, i.e. NH_4^+ ion in liquid ammonia will behave as an acid in liquid ammonia. For example, NH_4NO_3 ionizes in liquid ammonia according to the equation.

$$NH_4NO_3 \rightleftharpoons NH_4^+ + NO_3^-$$

This ionization produces NH_4^+ ion which is a cation charactristics of ammonia. Therefore, NH_4NO_3 will have as an acid in liquid ammonia.

Similarly any substance that can produce the anion charactristic of ammonia, i.e. NH_2^- ion, in liquid ammonia will behave as a base in liquid ammonia. For example, $NaNH_2$ ionizes in liquid ammonia according to the equation.

$$NaNH_2 \rightleftharpoons Na^+ + NH_2^-$$

This ionization produces NH_2^- ion, which is an anion characteristic of ammonia. Therefore, $NaNH_2$ will behave as a base in liquid ammonia.

The process of neutralization is the combination of ammonium ion and the amide ion.

$$NH_4^+ + NH_2^- \rightleftharpoons 2NH_3$$

For example :

$$NH_4NO_3 + NaNH_2 \rightleftharpoons NaNO_3 + 2NH_3$$

Usanovich concept A very comprehensive definition of acids and bases was proposed by Russian chemist Usanovich (1939). According to him, "An acid is any chemical species which reacts with bases, gives up cations, or accepts anions

or elections, or conversely, a base is any chemical species which reacts which acids, gives up anions or electrons, or combines with cations." The definition covers all Lewis acids and bases and includes redox reactions which may consist of complete transfer of one or more electrons. Some examples of acid-base reactions in terms of Usanovich concept are given below:

$$\text{Acid} \qquad\qquad \text{Base}$$
$$SO_3 \quad + \quad Na_2O \quad \rightarrow \quad Na_2SO_4$$

(acid SO_3 combines with anion O^{2-}; base Na_2O gives up anion O^{2-})

$$Sb_2S_5 \quad + \quad 3(NH_4)_2S \quad \rightarrow \quad 2(NH_4)_3SbS_4$$

(acid Sb_2S_5 combines with anion S^{2-}; base $(NH_4)_2S$ gives up anion S^{2-}).

$$Cl_2 \quad + \quad 2Na \quad \rightarrow \quad 2NaCl$$

(acid Cl gains an electron; base Na loses an electron).

$$Fe(CN)_2 \quad + \quad 4KCN \quad \rightarrow \quad K_4Fe(CN)_6$$

(acid $Fe(CN)_2$ combines with CN^- anions; base KCN gives up CN^-)

The unsaturation involved in certain acid-base reactions was also considered by Usanovich;

$$O=C=O \quad + \quad OH^- \quad \rightarrow \quad HOCOO^-$$
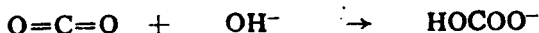
Thus we find that Usanovich concept is like a synthesis of all the previous acid-base theories and in the process it has become too general. Having gone through several concepts of acid-base reactions, it becomes difficult to make an appropriate choice for the best. As a matter of fact, each concept has its plus and minus points. In his book, Moeller has very rightly concluded the discussion on acid-base concepts with the remarks, "Actually each concept is correct as far as it goes, and knowledge of the fundamentals of all is essential."

Acid solvents, Basic solvents. Solvents which have a strong tendency to give protons are also called acid solvents, e.g.

liquid hydrogen fluoride, H_2SO_4, CH_3COOH. Solvents which have a strong affinity for protons are called basic solvents, e.g. liquid ammonia, pyridine, hydrazine, etc.

Actinide contraction. The ionic radius decreases regularly as we move across the actinides. It is because of the poor shielding of the nuclear charge by the 5f electrons. The decrease being analogous to lanthanide contraction is called actinide contraction.

Actinides. The fourteen elements, following actinium, Ac (atomic number 89) from thorium (at. no. 90) to lawrentium (at. no. 103) are called the actinides. They result from the filling of the 5f orbitals and are analogous to the lanthanides. Actinium, like lanthanum, is also included in the actinide series.

Thorium, protactinium and uranium are naturally occuring while the rest are artificially prepared. Elements following uranium are termed transuranic elements.

Every known isotope of the actinides is radioactive and it is only because the half-lives of $^{232}_{90}Th$, $^{235}_{92}U$ and $^{238}_{92}U$ are of the same order of magnitude, as the age of the earth that they are still surviving.

Thorium is widely distributed and its commercially important source is the monazite sand. Uranium is also widely distributed; its most important source is pitch blende, U_3O_8. The transuramic elements have been prepared artificially.

The elements are silvery white metals of high density with relatively high melting and boiling points. The metallic radii decrease sharply from Ac to U (table below) probably due to an increasing number of electrons being involved in metallic bonding. Thereafter (except Np and Pu) increasing metallic radius is presumbly a result of fewer electrons being involved in metallic bonding.

On the other hand, the ionic radii in a given oxidation state fall steadily and indicate that some sort of "actinide contraction" exists.

The metals are reactive and tarnish rapidly in air. They react with most non-metals especially if heated. The elements

do not react with alkalis and are less reactive towards acids. Th, U and Pu are rendered passive by conc. HNO_3. The presence of F^- ions prevents this and is the best method for dissolving the metals.

The magnetic moments of some ions of the actinides are shown in the following figure. The variations are compareble with the tripositive ions of the lanthanides.
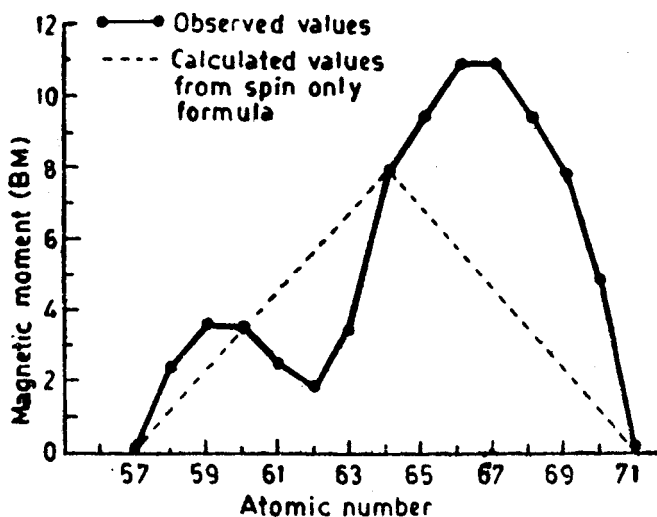
Magnetic moments of some actinide

Thorium is obtained from the mineral monazite sand, while the main source of uranium is pitch blende. Element 93, Np onwards are prepared by typical nuclear reactions.

For the first three elements, Th, Pa and U, the most stable oxidation state is that involving all the valence electrons. It decreases progressively until in the second half of the series, $+3$ state becomes dominant. The various oxidation states are listed below:

```
Ac Th Pa U Np Pu  Am  Cm Bk Cf Es  Fm  Md  No Lr
                +2          (+2) (+2) (+2)(+2)+2
+3(+3) (+3)+3+3+3+3   +3 +3 +3 +3 +3 +3  +3 +3
 +4   +4 +4+4+4(+4) (+4)+4
     +5 +5+5+5+5
       +6+6+6+6
         +7+7
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A bold type indicates the most stable oxidation state whereas the unstable states are included in parentheses.

Metallic and ionic radii of actinides

Element	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es
Metallic radius (pm)	179	163	156	155	169	173	174	170	185	186
Ionic radius M^{3+} (pm)	108	105	103	101	100	99	98	96	96	—
M^{4+}	99	96	93	92	90	89	88	83	82	—

Actinium. A toxic radioactive metallic element that is the first member of the actinides. It occurs in trace quantities in uranium ores and has been used as a source of alpha particles. Symbol: Ac; m.p. 1323 K; b.p. 3473 K (calc.); stablest isotope Ac (half-life 21.6 years).

Actinoids. (See actinides).

Air pollution. The atmospheric air is being increasingly polluted as a result of the disturbance of natural equilibrium caused by man and his technology. By the term 'air pollution' we understand the presence in the atmosphere of one or more contaminants or combinations thereof, in such amounts and of such durations that they are or may tend to be harmful to living organism or other materials. These atmospheric contaminants (pollutants) find their origin in factories, power plants and motor vehicles.

Alkali metals (Group IA elements). The IA group of the periodic table consists of lithium (Li) sodium (Na), potassium (K) rubidium (Rb), cesium (Cs) and francium (Fr). These elements are highly reactive metals, which form strongly alkaline oxides and hydroxides. So they are commonly called as the alkali metals. The main characteristics of the elements are listed below.

Physical Characteristics of Alkali Metals

Property	Li	Na	K	Rb	Cs
Atomic number	3	11	19	37	55
Atomic mass	6.94	23	39.10	85.48	133
Atomic radius ($\mathring{A}$)	1.23	1.57	2.03	2.16	2.35
Ionic radius ($\mathring{A}$)	0.60	0.95	1.33	1.48	1.69
Atomic volume	12.97	23.68	45.86	55.80	69.95
Density (g cm^{-3})	0.534	0.972	0.860	1.530	1.903
Ionization energy (kJ mol^{-1})	520	496	419	403	375
Electronegativity	1.0	0.9	0.8	0.8	0.7
Melting point (K)	454	371	336	312	302
Boiling point (K)	1,609	1,153	1,035	973	943
Heat of atomization (kJ mol^{-1})	163.6	104.2	83.3	79.5	75.7
Specific heat at 273 K	0.941	0.293	0.17	0.08	0.049
Flame coloration	Crimson	Yellow	Lilac	Violet	Violet
E°(V)($M^+ + e^- \rightarrow M$)	−3.04	−2.71	−2.92	−2.94	−2.99

The electronic configurations of the alkali metals are given below:

Element	At. no.	Electronic configuration	
Lithium	3	$2s^2, 2s^1$	or [He] $2s^1$
Sodium	11	$1s^2, 2s^2p^6, 3s^1$	or [Ne] $3s^1$
Potassium	19	$1s^2, 2s^2p^6, 3s^2p^6, 4s^1$	or [Ar] $4s^1$
Rubidium	37	$1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6, 5s^1$	or [Kr] $5s^1$
Cesium	55	$1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6, d^{10},$ $5s^2p^6, 6s^1$	or [Xe] $6s^1$
Francium	87	$1s^2. 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6d^{10}f^{14},$ $5s^2p^6d^{10}, 6s^2p^6, 7s^1$	or [Rn] $7s^1$

Thus all of them possess one electron in their outermost orbit and they exhibit monovalency.

Alkali metals in ammonia. The ability to dissolve the alkali metals is one of the striking features of liquid ammonia as a solvent. The alkali metal solutions in ammonia are blue in colour. The blue solution is characterized by:

Its colour which is independent of the metal involved,

Its density which is similar to that of pure ammonia,

Its conductivity which is in the range of electrolytes dissolved in ammonia, and

Its paramagnetism (i.e. these solutions when placed in a magnetic filed are attracted into the field) which indicates the presence of a large number of unpaired electrons.

The alkali metal solutions dissociate to form alkali metal cations and solvated electrons.

$$M \longrightarrow M^+ + [e(NH_3)_x]^-$$
dissolved in liq. NH_3

The dissociation into cation and anion accounts for the electrolytic conductivity of the blue coloured dilute solutions. As the concentration of the solution is increased, M^+ and e^- species associate resulting in a decrease of conductivity.

Very dilute solutions of alkali metals in liquid ammonia are meta-stable and when catalysed they undergo decomposition.

$$[e(NH_3)_x]^- \xrightarrow{Fe_2O_3} NH_2^- + \tfrac{1}{2}H_2 + (x-1)NH_3$$
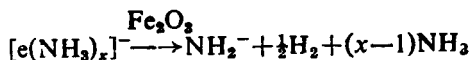
As the concentration of metal increases, the blue colour changes to bronze and finally the blue colour disappears altogether. On evaporating the alkali metal ammonia solutions, alkali metal can be recovered.

The blue colour of dilute metal ammonia solutions may be attributed to the presence of ammoniated cation and ammoniated electron.

$$M^+ + xNH_3 \rightleftharpoons [M(NH_3)_x]^+$$
ammoniated
cation

$$e^- + yNH_3 \rightleftharpoons [e(NH_3)_x]^-$$
ammoniated
electron
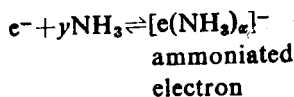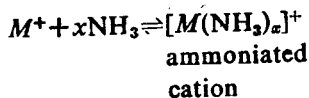
Alkaline earth metals. (Group IIA elements). The IIA group of the periodic table consists of beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra). Since these elements were alkaline and existed in the earth, they were called as alkaline earths, later on they were named as alkaline earth metals. All these metals consist of two electrons in their outermost s-orbital and closely resemble in physical and chemical properties. The main characteristics of the elements are listed below:

Physical Charecteristics of Group IIA Elements

Property	Be	Mg	Ca	Sr	Ba	Ra
Atomic number	4	12	20	38	56	88
Atomic mass	0.01	24.31	40.08	87.67	137.67	226.05
Atomic radius (A)	1.13	1.60	1.97	2.15	2.21	—
Ionic radius (A)	0.34	0.74	1.04	1.20	1.38	1.32
Atomic volume	4.90	13.97	25.91	34.54	36.72	38.00
Density $(g\ cm^{-3})$	1.85	1.74	1.54	2.6	3.5	6.00
Electronegativity	1.5	1.2	1.0	1.0	0.9	—
Melting point (K)	1553	924	1124	1073	1130	973
Boiling point (K)	2773	1383	1442	1423	1410	1413
Ionization energy $(kJ\ mol^{-1})$ Ist	899	737	590	550	503	510.5
2nd	1757	1450	1145	1064	965	972.8
E° (V) (M^{2+}/M)	—1.70	—2.37	—2.87	—2.89	—2.90	—
Heat of atomization $(kJ\ mol^{-1})$	327.2	147.3	177.8	163.6	176.6	—
Heat of hydration of ions $(kJ\ mol^{-1})$	2,406	1,929	1,632	1,485	1,276	—
Specific heat	0.452	0.246	0.168	—	0.368	—
Flame coloration	—	—	Brick red	Crimson	Apple green	Crimson

The electronic configurations of alkali metals are given below:

.Element	At. no.	Electronic configuration	
Beryllium	4	$1s^2, 2s^2$	or [He] $2s^2$
Magnesium	12	$1s^2, 2s^2p^6, 3s^2$	or [Ne] $3s^2$
Calcium	20	$1s^2. 2s^2p^6, 3s^2p^6, 4s^2$	or [Ar] $4s^2$
Strontium	38	$1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6, 5s^2$	or [Kr] $5s^2$
Barium	56	$1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6d^{10},$ $5s^2p^66s^2$	or [Xe] $6s^2$
Radium	88	$1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6d^{10}f^{14},$ $5s^2p^6d^{10}- 6s^2p^67s^2$	or [Rn] $7s^2$

Thus all of them possess two electrons in their outermost orbit and exhibit divalency.

Allotropes of antimony. Antimony exists in the following allotropic forms:

Yellow or α-antimony It is obtained by passing air through liquid stibine at 183 K.

$$4SbH_3 + 3O_2 \longrightarrow 4Sb + 6H_2O$$
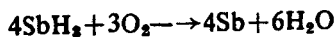
It is yellow non-metallic form of antimony. It is soluble in carbon disulphide. It is stable at low temperature and at room temperature it readily changes into black or β-antimony.

Black or β-antimony It is obtained as a black powder when yellow or α-antimony is allowed to stand at room temperature. It gradually changes into metallic form and rapidly on heating.

Explosive antimony It is obtained as steel grey powder by the electrolysis of antimony trichloride in hydrochloric acid using Pt cathode and Sb anode. On being heated or scratched it explodes and changes to metallic antimony followed by liberation of excessive heat. It is believed that explosive antimony is a solid solution of antimony chloride in yellow antimony.

Metallic antimony It is obtained as rhombohedral crystals by gradually cooling the fused antimony. It is grey coloured lustrous, very brittle and poor conductor of heat and electricity (m.p. 903 K, b.p. 1653 K, sp. gr. 6.58). Its structure is similar to that of metallic arsenic (Sb—Sb distance=0.5 Å).

Allotropes of arsenic. Arsenic exhibits three allotropic forms, viz. metallic or grey, yellow and black arsenic.

Metallic or grey arsenic It is the normal allotrope of arsenic grey in colour with dull metallic lustre, with sp. gr. 5.73. It sublimes at 886 K, giving yellow vapours. It is a good conductor of electricity. Its vapour density varies with temperature indicating the equilibrium $As_4 \rightleftharpoons As_2$. It is 98% As_4 at 1025 K and 98% As_2 at 1915 K. It nas layer-like structure with each atom having three equidistant pyramid-bonded atoms and three more neighbours of adjacent layer.

Yellow arsenic It is obtained by suddenly cooling of the arsenic vapours in a bath of liquid air in dark. It is unstable form with respect to other forms. It is solid like wax with sp. gr. 3.1. It is soluble in carbon disulphide and poor conductor of electricity. Like white phosphorus, it produces luminescence due to oxidation. It is non-metal (As—As=2.44 Å) just like white phosphorus.

Black arsenic This form of arsenic may be considered as an intermediate form of the above two mentioned forms. It may be obtained by dissolving yellow arsenic in carbon disulphide and allowing to stand for some time. It is black amorphous solid, poor conductor of electricity and less stable. Its sp. gr. is 4.6. It does not oxidize in air or nitric acid upto 355-365 K. It changes into metallic form by heating to 635 K in a tube.

Allotropes of white arsenic. There are three allotropes of white arsenic:

Amorphous form It is obtained by the condensation of arsenious oxide vapours very slowly below 475 K. It is a colourless amorphous form with glassy appearance. It is slightly soluble in water, and sublimes at 475 K. Its sp. gr. is 3.74. In air it gradually changes into octahedral crystalline form.

Crystalline octahedral form. It is obtained by the rapid condensation of arsenious oxide vapours or on standing amorphous form in air for long time (m.p. 548 K, sp. gr. 3.69). It is the most stable form.

Crystalline monoclinic form It is obtained by prolonged heating of the above forms at 475 K or by the crystallization of aqueous solution of arsenious oxide in the presence of potassium hydroxide (m.p. 588 K, sp. gr. 3.85).

Allotropy. The existence of more than one form of an (uncombined) element is known as allotropy. Oxygen exhibits several allotropic forms (or allotropes); the most common are ordinary oxyen, O_2 and ozone, O_3.

Alloy. It is a mixture of two or more metals (e.g. bronze or brass) or of a metal with small amounts of non-metals, (e.g. steel). Alloys may be completely homogeneous mixtures or may contain small particles of one phase in the other phase.

Alnico. Any of a group of very hard brittle alloys used to make powerful permanent magnets. They contain nickel, aluminium, cobalt, and copper in different amounts. Iron, titanium, and niobium may also be present. They have a high remanence and coercive force.

Alpha particle. A particle which is commonly ejected from a nucleus lying beyond the trough of stability is the alpha particle. It is a complex particle composed of two protons and two neutrons and is identical to a helium nucleus.

Alumina. Hydrated alumina is the natural bauxite mineral, $Al_2O_3.nH_2O$ ($n=$1-3). Pure Al_2O_3 can be prepared in the laboratory by heating aluminium hydroxide or ammonium alum.

Freshly prepared alumina reacts with both acids and alkalis showing its amphoteric nature.

$$Al_2O_3 + 6H^+ \longrightarrow 2Al^{3+} + 3H_2O$$
$$Al_2O_3 + 2OH^- + 2H_2O \longrightarrow 2[Al(OH)_4]^-$$
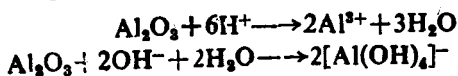
Alumina is a refractory material used in the manufacture of heat resistant bricks and for the internal lining of furnaces. As a finely divided powder, it is often used as the adsorbing stationary phase in column chromatography. Alumina can be fused with oxides of chromium, iron and cobalt to form synthetic semi-precious stones. It is also used as a dehydrating agent, e.g.

$$CH_3—CH_2—OH \xrightarrow[575\ K]{Al_2O_3} H_2C=CH_2+H_2O$$
$$\text{ethanol} \qquad \text{ethylene}$$
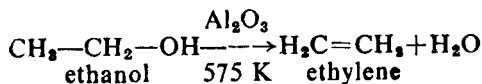
Aluminium. [Latin *alumen, aluminis*, alum]. A Group IIIA element of the third period of the Periodic Table of elements, atomic number 13, atomic mass 26.9815, one stable isotope, ^{27}Al (100 per cent). Aluminium metal was obtained by Wohler in 1827. Third to oxygen and silicon in abundance in earth's crust (8.8 per cent); various aluminosilicates containing these three elements make up 82 per cent of crust's mass. Does not occur in the free form: the most important source of aluminium is bauxtie.

Properties A silvery white metal, light, firm, ductile, a good conductor of heat and electricity. A highly reactive element, valence $+3$. Combines with oxygen and is covered by an oxide film, Al_2O_3 when stored in the air. This explains high corrosion resistance of aluminium. Remains unattacked under the action of conc. HNO_3. Readily dissolves in alkalis, dilute HCl and H_2SO_4. Like Al_2O_3 aluminium hydroxide is amphoteric: in aqueos solutions, it reacts with acids to give a hydrated ion, $[Al(H_2O)_6]^{3+}$, and with alkalis to give metal aluminates.

Extraction By the electrolysis of aluminium oxide made from bauxite and dissolved in molten cryolite, Na_3AlF_6.

Uses The production of light alloys (Dural, Silumin) for aircraft, automobiles; employed as building material, as material for chemical equipment, in the manufacture of electric wire, capacitors, in building of nuclear reactors Aluminium is employed as reducing agent in metallurgy Various aluminium compounds have practical applications.
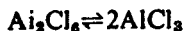
Aluminium oxide, aluminium chloride, $AlCl_3$, and hydrated aluminium chloride, $AlCl_3.6H_2O$, are used as catalysts in the organic synthesis, aluminium sulphate, $Al_2(SO_4)_3.18H_2O$, and and potassium alum, $KAl(SO_4)_2.12H_2O$, as mordants in dyeing, for tanning leather, in th manufacture of paper, and in the purification of water. Silver paint used in building and architecture for protecting from corrosion and for decorative purposes in a mixture of aluminium powder and mineral oil. Organoaluminium compounds are employed as starting material for the synthesis of other organometallics; alkylaluminium derivatives are catalysts for the polymerization of olefines.

Aluminium chloride. Anhydrous aluminium chloride, Al_2Cl_6 is prepared by passing dry chlorine or HCl gas over heated aluminium powder

$$2Al + 3Cl_2 \longrightarrow Al_2Cl_6$$
$$2Al + 6HCl \longrightarrow Al_2Cl_6 + 3H_2$$
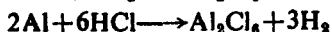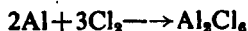
The other halides, viz. aluminium bromide and aluminium iodide can also be prepared by the action of corresponding halogen on the metal.

From the molecular mass determinations in organic solvents and in the vapour state (upto 658 K), it is inferred that the compound exists in the dimeric from. At high temperature (1000 K) it dissociates into monomer.

$$Al_2Cl_6 \rightleftharpoons 2AlCl_3$$

Anhydrous Al_2Cl_6 reacts with water to give hydrated aluminium chloride, $AlCl_3.6H_2O$.

$$Al_2Cl_6 + 12H_2O \longrightarrow 2AlCl_3.6H_2O$$
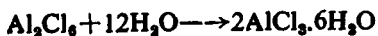
The use of anhydrous aluminium chloride as a catalyst in Friedel·Crafts reaction is well known. It is also used in petroleum cracking and in the manufacture of dyes, drugs and perfumes.

Aluminium hydride (Alane). AlH_3 It is prepared by the reaction of lithium hydride with aluminium chloride in dry ether.

$$3LiH + AlCl_3 \longrightarrow 3LiCl + AlH_3$$