

EARLIEST APPLIED CHEMISTRY



The earliest applications of chemical processes were concerned with extraction and working of metals and manufacture of pottery.

These arts were carried out without any theoretical background, but often with considerable skill.

Before the finding of metals, usually their implements were made of stone, horn or bone.

The 1st metal known was probably gold. This metal occurs in the native mettalic form in some river sands and would attract attention by its color and lustre. The earliest gold was probably obtained as a small nuggets by washing alluvial deposit.

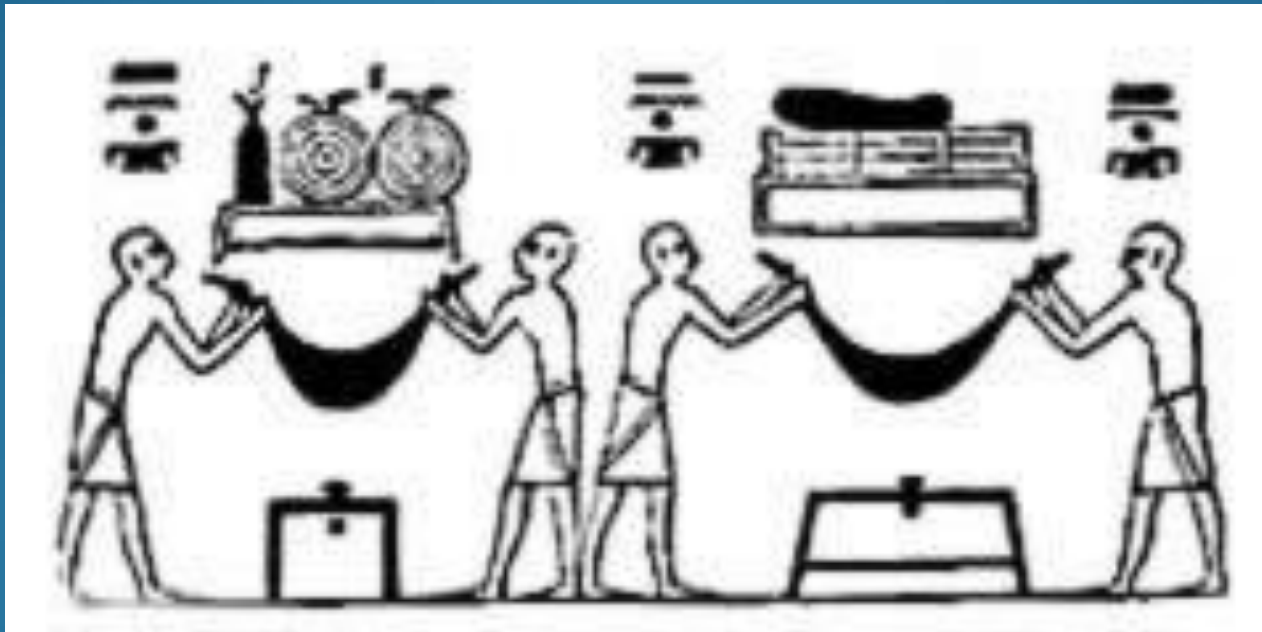


Fig 1. Gold washing in ancient Egypt (4000 BC)

The next metal known was probably copper and some think it was known even before gold in Egypt. The Egyptian copper was probably obtained by reducing the ore malachite (the basic copper carbonate) from Sinai in charcoal fires.



Fig 2. Sumerian copper statuette (3300 BC)

The earliest known working in metals appears before 3400 BC in Egypt and Mesopotamia, and rather later in the island of Crete, in the Mediterranean. Egypt and Mesopotamia are rivals in the claim for the origin of the working of metals. The Sumerians (the ancient inhabitants of Mesopotamia) were expert in the working of gold, silver and copper.



Fig 3. Silver vase of Entemena (2850 BC)

Gold and copper also occurs in the island of Crete, which was the centre of an old civilization known as the Minoan. The Cretans probably learnt the use of metal from Egypt, with which they were in relation from the earliest times.



Fig 4. Minoan Gold Cup (1500 BC)

A great advance in metal working was the invention of bronze, an alloy of copper and tin. The earliest Egyptian bronze is dating to about 3000 BC.

The big question : “Where did the tin came from?”
(nowadays, there are no tin mines in both of Egypt and Mesopotamia)

Egyptian and Mesopotamian bronzes sometimes contain lead in place of tin and sometimes antimony (as do some early Chinese bronzes).

The metal iron, silver and lead were also known in Egypt, soon after copper and gold (about 3400 BC).

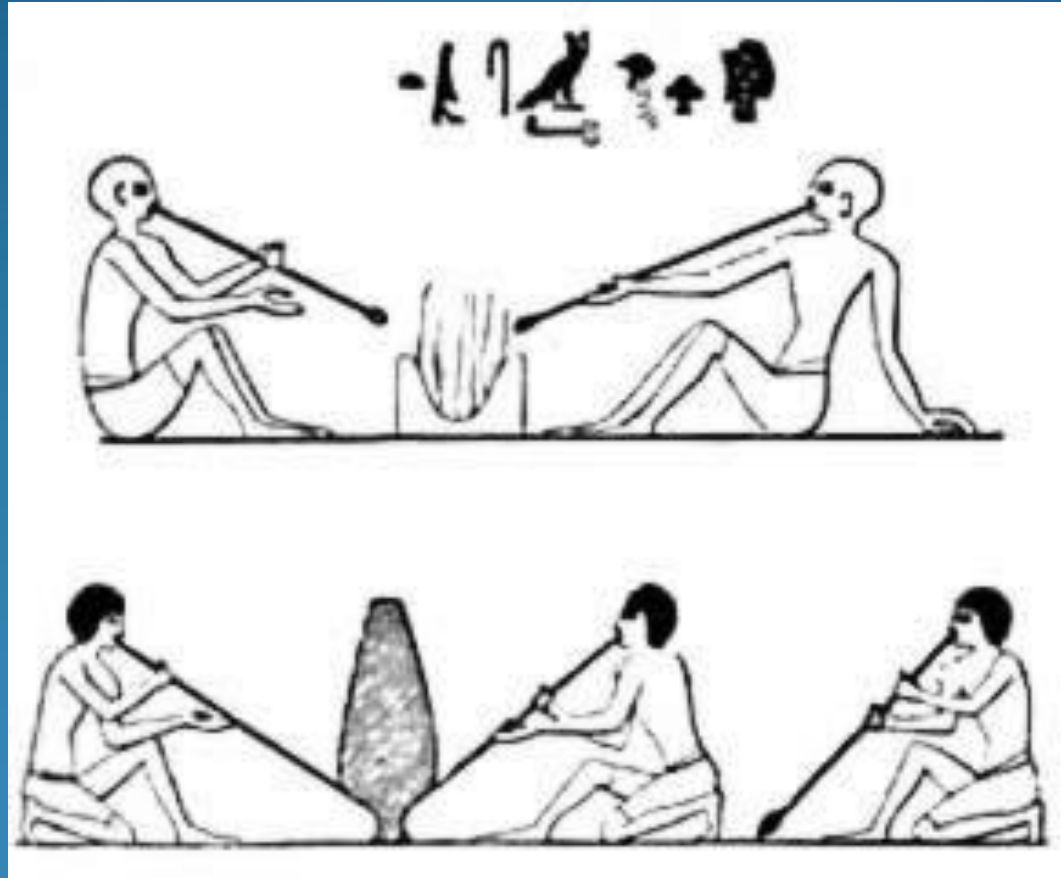


Fig 5. Egyptian Metal Working (a copper vase)

The early iron was very scarce and was probably (since it contains nickel) obtained from meteorites.

Iron tools were found in the pyramid of Cheops (2900 BC) and do not contain nickel. Iron was used sparingly in Egypt about 2000 BC, which come from the Land of the Hitties, in Asia Minor, around the Black Sea. The Hittites promising a *steel* dagger and asking for gold in exchange.

The metal *Orichalcum* (mentioned by Plato), may have been brass, was found in Palestine at 1200 BC.



Fig 6. Roman's Coin, made from brass (100 M)

The Egyptian potter very soon learnt the use of the wheel for moulding the clay and the vessels were baked in tall closed furnaces, not in open fire.



Fig 7. Egyptian making pottery with furnace

The manufacture of glass on the large scale apparently began in Egypt about 1370 BC. The alkali (*natron*, sodium carbonate found in Egyptian lakes near Alexandria) was melted with crushed quartz in crucibles.

A deep blue color (“Egyptian blue”) was made in Egypt by heating silica with malachite and lime in the temperature range 830 – 900 °C.

Some early specimens of Egyptian and Babylonian blue glass are colored with cobalt.

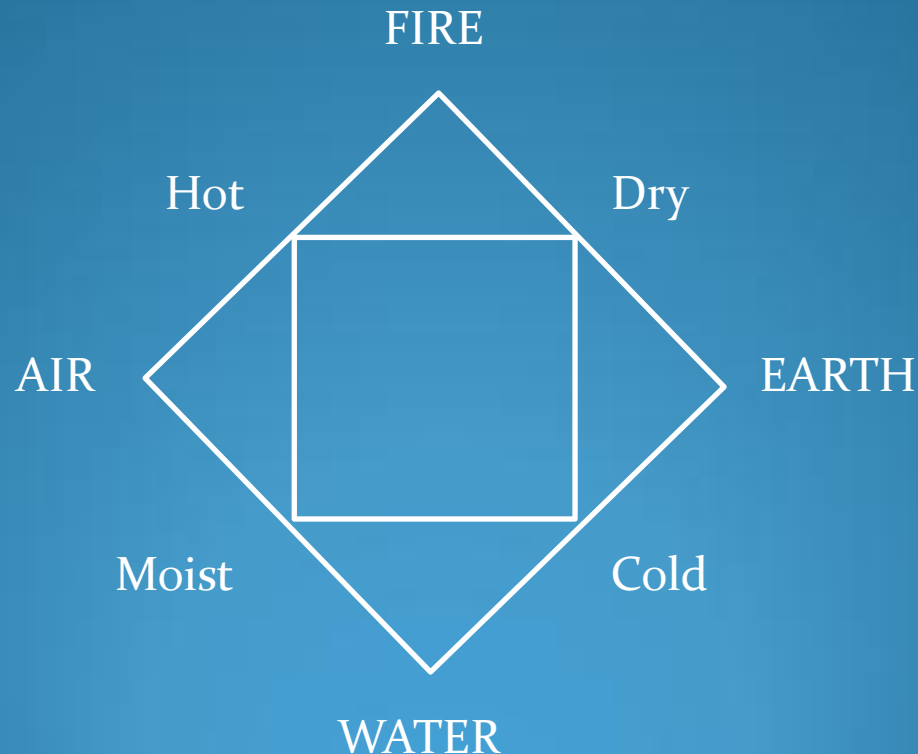
THE BEGINNINGS OF CHEMISTRY

The name of “elements” (*stoicheia*) was first used by Plato (427 – 347 BC), who assumed that things are produced from a formless primary matter, perhaps just space, taking on “forms”.

Aristotle (384 – 322 BC) developed the view that all substances were made of a primary matter, called “*hulē*”.

Aristotle defined an element or “simple body” as “one of those bodies into which other bodies can be decomposed and which itself is not capable of being divided into others”.

Aristotle took as the fundamental properties of matter. By combining these in pairs, he obtained what are called “*THE FOUR ELEMENTS*”. This theory persisted until towards the end of 18th century.



Aristotle's idea :

1. Early idea of transmutation
2. He distinguished between mechanical mixture and solution and chemical change with complete change of properties.
3. Mercury as “silver water” (*chutos arguros*)
4. He says that the vapour from sea water evaporated in a vessel condenses as a fresh water on the cool lid and (wrongly) that wine would give water in a similar way (DISTILLATION)
5. He concluded that metals are mostly water.

The first clear expression of the idea of an element occurs in the teachings of the Greek philosophers.

1. Thales (640 – 546 BC) supposed that all things were formed of water;
2. Anaximenes (560 – 500 BC) of air;
3. Herakleitos (536 – 470 BC) of fire;
4. Empedokles (490 – 430 BC) introduced the ideas of four “roots” of things: fire, air, water, earth; and two forces, attraction and repulsion which joined and separated them.

CHEMICAL KNOWLEDGE OF CLASICAL PERIOD

Dioskurides (60 M) and Pliny the Elder (23 – 79 M, the author of the famous “History of Nature”) were described several chemical substances, such as the oxide of copper, iron, and zinc; alum; the sulphates of copper and iron; vegetable and animal products, including dyes, and with some simple chemical operations, such as the working of metal and alloys, amalgams, and testing gold and silver for purity.

Theophrastos (315 BC) describing some chemical operations, e.g. manufacture of white lead (Greek, *psimuthion*).

“lead is placed in an earthen vessel over sharp vinegar and after it has acquired some thickness of a kind of rust, which it commonly does in about ten days, they open the vessels and scrape it off. They then place the lead over the vinegar again, repeating over and over again the same process of scraping it till it is wholly gone. What has been scraped off they then beat to powder and boil (with water) for a long time and what at last settles to the bottom of the vessel is white lead” (*Treatise on Stones*)

Pliny describes the preparation of mercury :

“They put minium (cinnabar from Spain) in an earthen vessel well luted over with clay, upon which there is set a pan of iron, and the same covered over the head with another pot, well cemented. Under the earthen pot a good fire is made and kept continually blown. And thus by circulation there will appear a dew or sweat in the upper most vessel, proceeding from the vapours set free. When this is wiped off it will be as liquid as water but in color will resemble silver”

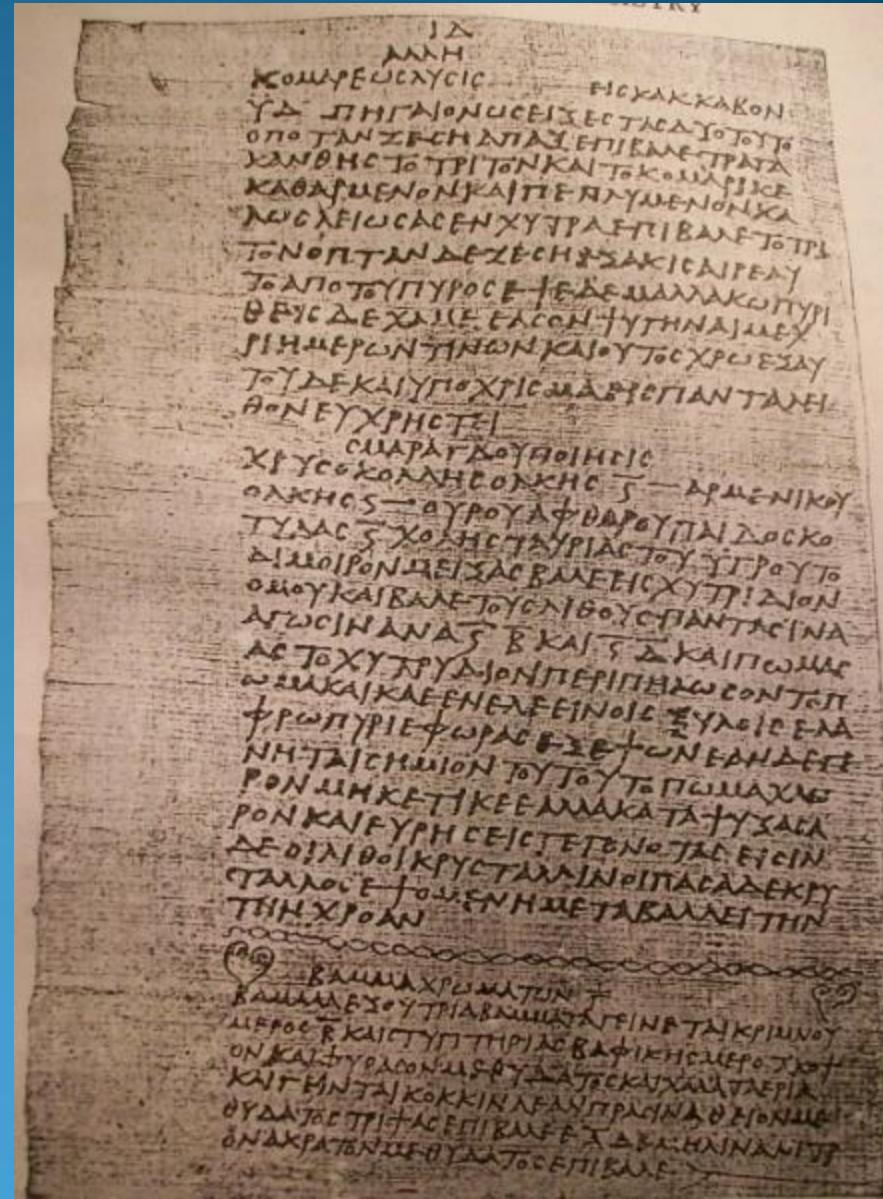
THE CHEMICAL PAPIRY (*LEYDEN PAPIRUS*)

A collection of Egyptian recipes discovered in 1928 in a tomb at Thebes in Egypt. The papyrus is written in Greek at a date probably round 300 M.

“One powders up gold and lead into a powder as fine as flour, 2 parts of lead for 1 of gold and having mixed them, works them up with gum. One covers a copper ring with the mixture; then heats. One repeats several times until the object has taken the color. It is difficult to detect the fraud, since the touchstone gives the mark of true gold. The heat consumes the lead but not the gold”

THE CHEMICAL PAPIRY (STOCKHOLM PAPIRUS)

Mix together and put into a pot 2 grams of malachite, 2 grams of azurite, 130 cc of the urine of a young boy and 180 cc of solution of ox-gall. Put into the pot all the twenty-four pieces of stone, each weighing of 27 grams. Put the lid on the pot and lute it around with clay. Heat for six hours over a gentle fire of olive wood. When you see the lid has become green, do not heat any more but allow to cool and take out the stones, whwn you will find that they have become emeralds



ALEXANDRIA

It was a modern city in Egypt which was founded by Alexander the Great at the mouth of the Nile river in 331 BC. This city had a mixed population of native Egyptian, Greeks, Syrian, and Jews, but was essentially Greek in culture. It contained a temple of the god Serapis, two Libraries and Museum (or university?).

The name of “chemistry” first occur in Alexandria in 296 M, the Emperor Diocletian. There was a book, which had the title “*chēmeia*”. The contents of this book were making (imitating) gold and silver.

The word appears in the Greek authors who report this as “*χημεία*” in a Greek manuscript now at St. Mark’s in Venice, from a work by Zosimos of Panopolis (300 M).

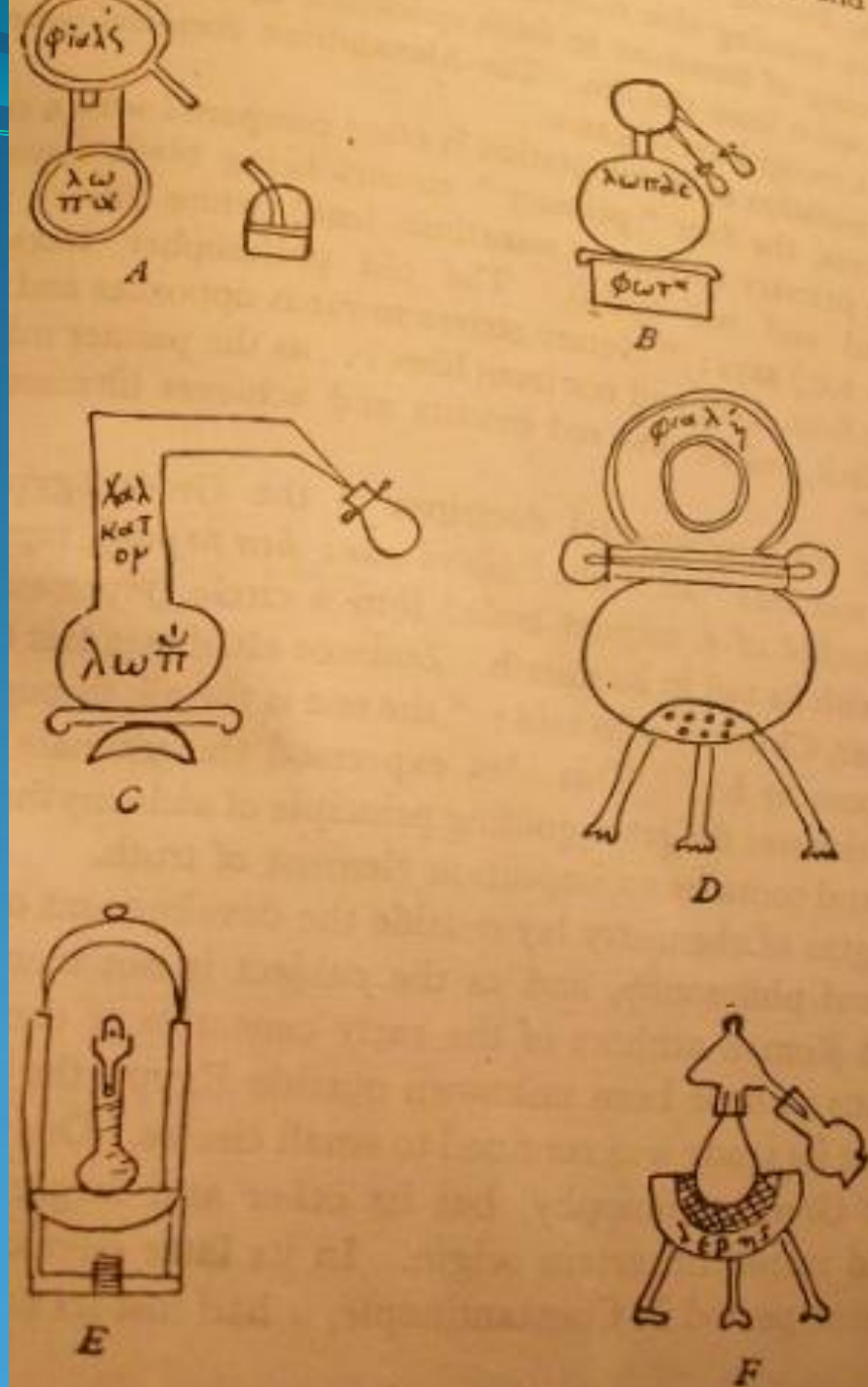
Illustrations of Chemical Apparatus (Zosimos)

A, B, C, F : distillation (Ambix /Alembic)

→ The lower part is called “lopas” and
the upper “phiale”

D : sublimation (Kerotakis)

E : heating apparatus



“χημεία” or “*chēmeia*” probably meant “the Egyptian art” and never had the meaning of a “black art” applied to magic.

The work of Zosimos contains interesting descriptions and illustrations of chemical apparatus and experiments, but also some mystical matter.

PLANET

Ἥλιος	Sun
Σελήνη	Moon
Κροῦος	Saturn
Ζεὺς	Jupiter
Αρης	Mars
Αφροδιτη	Venus
Ερμης	Mercury

SYMBOL

	gold
	silver
	lead
	bronze
	mixed metal
	tin
	iron

The important feature of Alexandrian treatises was “transmutations”. The process was to be effected by “changing the color”, e.g. Copper turned white by arsenic.

The transmuting agent was latter called by the Arabs “aliksir” (elixir).

Another things to note is that Zosimos distinguishes between what he calls “bodies”, by which he usually means metals, and “spirits”, by which he understands the vapours of arsenic, sulphur and mercury, which exert a powerful action on metals.

TO BE CONTINUED ...