CEREMICS

B.Tech 1st Year CS

Engineering Chemistry

The word ceramic comes from the Greek word "Keramikos" which means "burnt material"

Definition:

A ceramic is an inorganic non-metallic solid prepared by the action of heat and subsequent cooling

Raw materials:

Majority of raw materials used by ceramic industries are oxides of metals, clay, flint and feldspar are most widely used and referred to in the industry as "Classical ceramic bodies"

Raw materials

Oxides:
Alumina (Al_2O_3), Zirconia (ZrO_2)

Non-Oxide:
Carbide (CaC_2), boride (SiB_2), nitrides (Ca_3N_2), silicide (silicon with more electropositive elements, KSi)

Composites:
particulate reinforced (combinations of oxides and non-oxide)

Clay:

Clays are hydrated aluminosilicates ($Al_2O_3.2SiO_2.2H_2O$). Clay provides plasticity to facilitates the fabrication of material in to desired form prior to heat treatment.

Flint:

Flint is a form of SiO_2 usually produced from sand or rock. It is used in a finely pulverized form as a filler to give clay and final product the desired properties

Feldspar:

Feldspar is a broad, generic name applied to a group of alkali-aluminosilicate.
Potash feldspar ($K_2O.AL_2O_3.6SiO_2$) and in case of Na ($Na_2O.Al_2O_3.6SiO_2$) is soda feldspar.
Most feldspar however are combinations of these two types, it is known as flux in ceramic industry

Flux plays a key role in the vetrification of clay bodies by reducing the overall melting point.

Manufacturing process: Following steps are involved

a) Weighing of raw material
b) Mixing
c) Calcining
d) Spray drying
e) Pressing
f) Binder burn out.

The first step to weigh, dry and ball mill machine mix the raw materials. The uniform mixture is then subjected to calcining during which the component reacts to form the polycrystalline component. The calcined powder is allowed for spray drying followed by adding binder (polyalkanine carbonate), in order to increase its reactivity and pressing property.

After proper shaping by dry pressing. the binder is burnt out by slowly heating at around 700°C.

The parts are sintered (Part of firing process) at 1300°C

Types of ceramic products:

DIVIDED IN FOUR SECTOR

1. STRUCTURAL, INCLUDING BRIKS, PIPES, FLOOR AND ROOF TILES.
2. REFRACTORORY GAS TURBINE, STEEL AND GLASS MAKING CRUCIBLE.
3. WHITE WARES INCLUDING TABLE WARES, WALL TILES, POTTERY PRODUCTS AND SANITORY WARES
4. TECHNICAL ALSO KNOWN AS ENGINEERING WHICH INCLUDES TILES, SPACE SHUTTLE PROGRAM, GAS BURNER NOZZLES, BIOMEDICAL IMPLANTS, JET ENGINE TERBINE BLADDER AND MISILE NOSE CONE

Applications of ceramics:

Besides numerous conventional uses of ceramics are also used in…

1. In the manufacture of knives being stay sharp for much longer than of a steel knife although it is more brittle.

2. Ceramic such as alumina and boron carbide have been used in ballistic armored vests to repel large caliber rifle fire.

3. Ceramic ball can be used to replace steel in ball bearing. Ceramic are also more chemically resistant and can be used in wet environment where steel bearing rust. The main drawback is higher cost.

4. Ceramic are capable to work at very high temp. and do not require a cooling system and allow a major weight reduction and therefore greater fuel efficiency.

5. Ceramics finds prospects in the medical sciences also. bio ceramics such as dental implants and synthetic bone is in the market to be used as bone replacement or synthetic bone.

6. High-tech ceramics are used in watch making for producing watch cases for its light weight, scratch resistance and durability.

ANALYSIS OF COAL

Coal is a fossil fuel which occurs in layers in the earths crust. It is formed by the partial decay of plant materials accumulated millions of years of ago and further altered by action of heat and pressure.

The process of conversion of wood into coal can be represented as

Wood Peat Lignite Bituminous Anthracite

1) Peat: Peat is brown-fibrous jelly like mass.
2) Lignite: these are soft, brown colored, lowest rank coals
3) Bituminous coals: These are pitch black to dark grey coal
4) Anthracite: It is a class of highest rank coal

Fuel	Percentage of carbon	Calorific value (k.cal/kg)	Applications
Wood	50	4000-5000	Domestic fuel
Peat	50-60	4125-5400	Used if deficiency of high rank coal
Lignite	60-70	6500-7100	For steam generation in thermal power plants
Bituminous	80-90		In making coal gas and Metallurgical coke
Anthracite	90-98	8650-8700	In households and for steam raising

Analysis of Coal

The analysis of coal is helpful in its ranking. The assessment of the quality of coal is carried out by these two types of analyses.

A) Proximate analysis

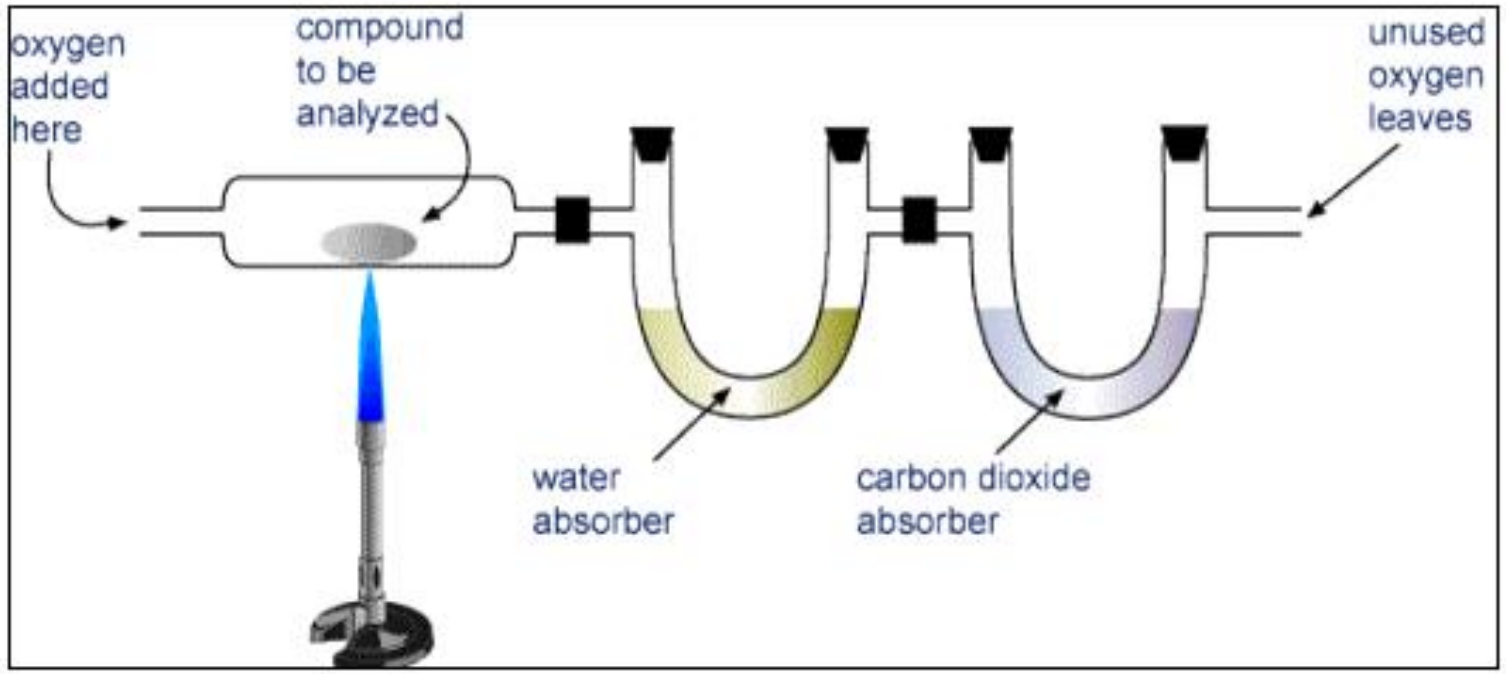
B) Ultimate analysis

Ultimate analysis:

This is the elemental analysis and often called as qualitative analysis of coal. This analysis involves the determination of carbon and hydrogen, nitrogen, sulphur and oxygen.

Determination of Carbon and Hydrogen:

About 1 to 2 gram of accurately weighed coal sample is burnt in a current of oxygen in a combustion apparatus. C and H of the coal are converted into CO_2 and H_2O respectively. The gaseous products of combustion are absorbed respectively in KOH and $CaCl_2$ tubes of known weights.



CaCl2 tube absorbs moisture:

$$CaCl_2 + 7\,H_2O \longrightarrow CaCl_2.7H_2O$$

While KOH bulb absorbs CO2:

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

We observed that

- The increase in weight of CaCl2 tube represents the weight of water formed
- The increase in weight of KOH bulb represents the weight of CO2 formed.

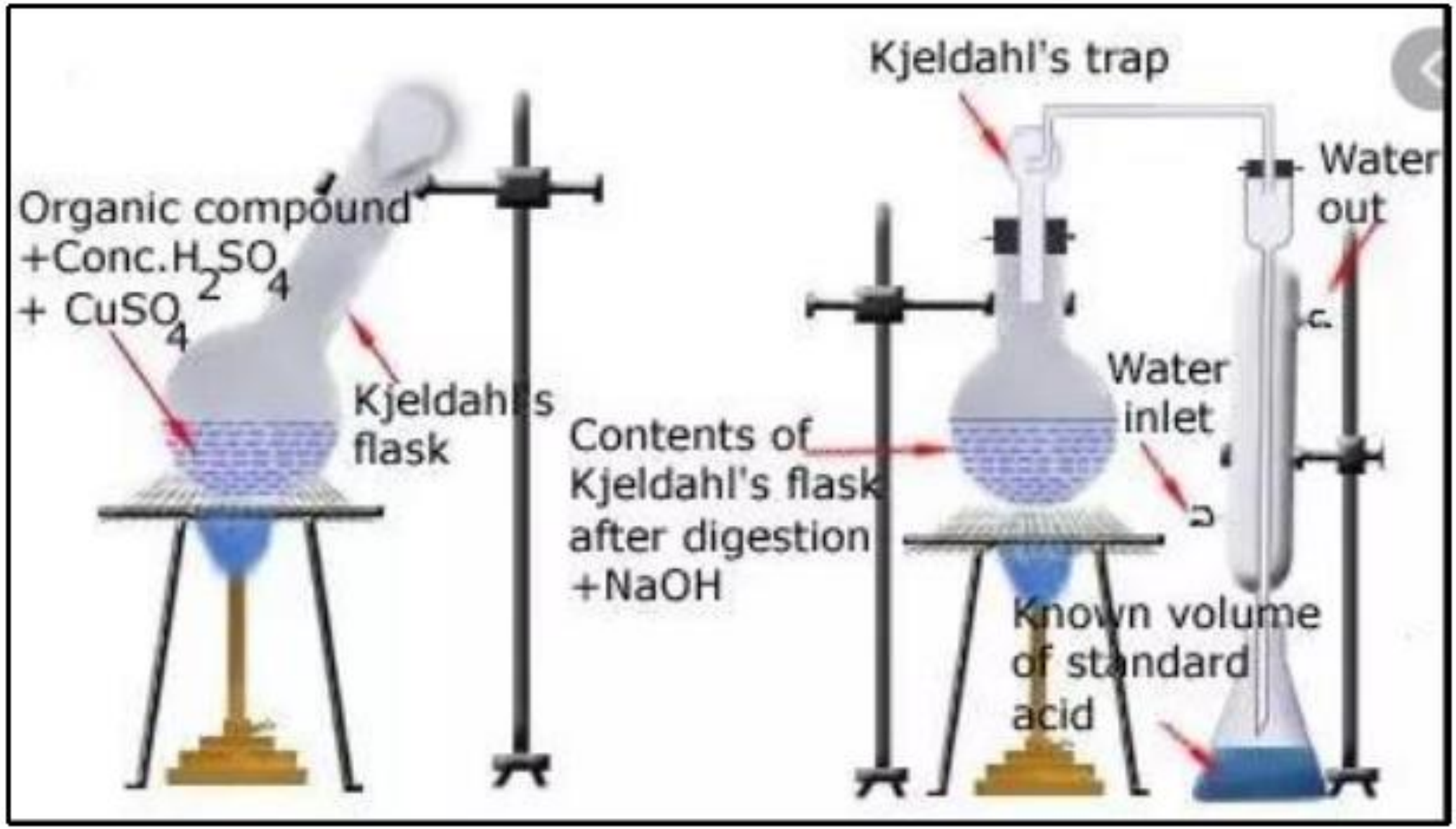
$$\text{Percentage of Carbon} = \frac{\text{Increase in weight of KOH tube} * 12 * 100}{\text{weight of coal sample taken} * 44}$$

$$\text{Percentage of Hydrogen} = \frac{\text{Increase in weight of KOH tube} * 2 * 100}{\text{weight of coal sample taken} * 18}$$

Determination of Nitrogen: A good coal should have very little nitrogen content.

Kjeldahal's Method:

About 1 gram of accurately weighed powdered coal is heated with concentrated H_2SO_4 along with K_2SO_4 and $CuSO_4$ (catalyst) in a long-necked Kjeldahal's flask. After the solution becomes clear (when whole nitrogen is converted into ammonium sulphate), it is treated with excess of KOH and the liberated ammonia is distilled over and absorbed in a known volume (V_1) of standard H_2SO_4 solution (0.1 N). The unused acid is then determined by back titration with standard NaOH solution(0.1N).


Organic compound
+Conc.H_2SO_4
+ $CuSO_4$
Kjeldahl's flask
Contents of Kjeldahl's flask after digestion +NaOH
Kjeldahl's trap
Water out
Water inlet
Known volume of standard acid

$$N_2 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

$$(NH_4)_2SO_4 + 2\,NaOH \longrightarrow 2Na_2SO_4 + 2NH_3 + 2H_2O$$

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

Let V_2 ml of 0.1 N NaOH was required to neutralize excess acid, the percentage of N in coal is calculated as follows:

$$\textbf{Percentage of Nitrogen} = \frac{0.1\,(V_1 - V_2)}{\textbf{Weight of coal taken}} \times 1.4$$

Determination of Sulfur: Although sulfur increases the calorific value of, on oxidation it produces harmful and corrosion causing SO_2 and SO_3 gases.

A known amount of coal is burnt in bomb calorimeter in presence of oxygen, by which Sulphur present in coal is converted into sulphates. The ash obtained in bomb calorimeter is treated with dil HCl. It is then treated with Barium chloride solution, when barium sulphate is precipitated. This precipitate is filtered, washed and heated to constant weight.

$$\textbf{Percentage of Sulfur in coal} = \frac{\textbf{Weight of } BaSO_4 \textbf{ ppt} \times 32}{\textbf{Weight of coal taken} \times 233} \times 100$$

Determination of Oxygen:

It is determined indirectly by deducting the combined percentage of carbon, hydrogen, nitrogen, sulphur and ash from 100.

Percentage of Oxygen = 100 – percentage of (C + H + S + N + Ash)

Significance of ultimate analysis:

Carbon and Hydrogen: Greater the percentage of carbon and hydrogen better is the coal in quality and calorific value. However, hydrogen is mostly associated with the volatile mater and hence, it affects the use to which the coal is put.

Nitrogen: Nitrogen has no calorific value and hence, its presence in coal is undesirable. Thus, a good quality coal should have very little nitrogen content.

Sulphur: Sulphur, although contributes to the heating value of coal, yet on combustion produces acids like SO_2, SO_3, which have harmful effects of corroding the equipment's and also cause atmospheric pollution. Sulphur is, usually, present to the extent of 0.5 to 0.3% and derived from ores like iron, pyrites, gypsum, etc., mines along with the coal. Presence of sulphur is highly undesirable in coal to be used for making coke for iron industry. Since it is transferred to the iron metal and badly affects the quality and properties of steel. Moreover, oxides of sulphur pollute the atmosphere and leads to corrosion.

Oxygen: Oxygen content decreases the calorific value of coal. High oxygen-content coals are characterized by high inherent moisture, low calorific value, and low coking power. Moreover, oxygen is a combined form with hydrogen in coal and thus, hydrogen available for combustion is lesser than actual one. An increase in 1% oxygen content decreases the calorific value by about 1.7% and hence, oxygen is undesirable. Thus, a good quality coal should have low percentage of oxygen.

Thank you