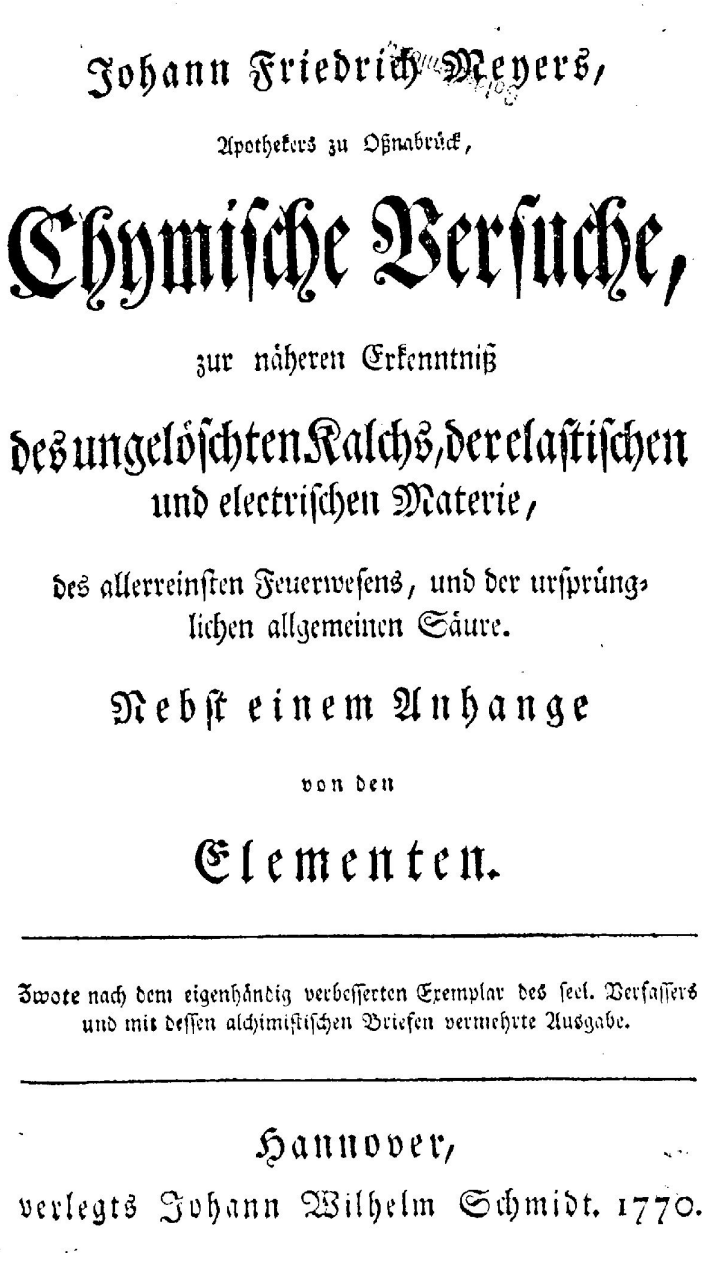
Lecture 15
Meyer's Theory of Lime
Black's Experiments

Patrick Maher

Scientific Thought II
Spring 2010

Johann Friedrich Meyer



Johann Friedrich Meyers,

Apothekers zu Oßnabrück,

Chymische Versuche,

zur näheren Erkenntniß

des ungelöschten Kalchs, der elastischen und electrischen Materie,

des allerreinsten Feuerwesens, und der ursprünglichen allgemeinen Säure.

Nebst einem Anhange

von den

Elementen.

Zwote nach dem eigenhändig verbesserten Exemplar des seel. Verfassers und mit dessen alchimistischen Briefen vermehrte Ausgabe.

Hannover,

verlegts Johann Wilhelm Schmidt. 1770.

1705: Born in Osnabrück, Germany.

1720: Apprentice in his grandmother's apothecary shop.

1737: Inherited his grandmother's shop.

1764: Published a book on lime (2nd ed. shown here).

1765: Died in Osnabrück.

1766: French translation of book published.

Meyer's theory of lime

- When calcareous earth is calcined, water is driven off and a substance called *causticum* is added from the fire.

$$\text{lime} = \text{calcareous earth} - \text{water} + \text{causticum}$$

- Causticum is what gives lime its causticity.
- There is a loss of weight because the water driven off weighs more than the causticum that is added.

This is similar to the fire theory.

Marggraf's experiment

Review

- Marggraf distilled calcareous earth, getting quicklime in the retort. The water obtained in the receiver was 3% of the weight of the calcareous earth.
- Black argued that, since calcareous earth can't be reduced to quicklime without losing at least 1/3 of its weight, most of the lost weight must be due to air being driven off. He cited this as support for his view that calcareous earth contains a large quantity of air.

Meyer's response

- Meyer said distillation isn't a good way to study lime because fire creates products that weren't present originally.
- He is right that fire creates new products. For example, alkali is obtained from burning plants but the alkali isn't in the plant before burning, it is produced during the combustion of the plant. This was known to chemists at the time.
- So, Marggraf's experiment doesn't show that calcareous earth contains air; the air may have been generated during the calcination.
- Meyer seems to have thought that air was generated from water and impurities such as salt.

Meyer's explanations of known facts

Why calcareous earth effervesces in acids

- Meyer noted that metals effervesce and lose weight in acid, though everyone (even Black) agreed they don't contain air.
- So Meyer said that the air of effervescence comes from the acid, not from the body being dissolved.
- Hence, when calcareous earth dissolves in acid, the air comes from the acid, not from the calcareous earth.

Why lime is soluble in water and calcareous earth isn't

- Meyer noted that calcareous earth dissolves in acids and this is the only known way to dissolve calcareous earth. Since lime = calcareous earth + causticum, and lime is soluble, Meyer inferred that causticum is an acid.
- So for Meyer, lime is soluble because it is a combination of an acid (causticum) with calcareous earth.

Why a crust forms on lime water

Meyer's explanation is that causticum in the lime goes into the air, leaving calcareous earth at the surface of the water.

Why lime makes alkalis caustic

Meyer said causticum in the lime transfers to the alkali, making the alkali caustic.

Black's experiments

Calcareous earth in acid (194)

I saturated two drams of chalk with diluted spirit of salt, and used the Florentine flask . . . Seven drams and one grain of the acid finished the dissolution, and the chalk lost two scruples and eight grains of air.

Florentine flask

- Spirit of salt is an acid obtained by distilling table salt.
- 1 dram = 3 scruples and 1 scruple = 20 grains, so

$$\frac{\text{weight lost}}{\text{weight of chalk}} = \frac{48 \text{ grains}}{120 \text{ grains}} = 40\%$$

Weight loss in calcination (195)

Two drams of chalk were converted into a perfect quick-lime, and lost two scruples and twelve grains in the fire.

$$\frac{\text{weight lost}}{\text{weight of chalk}} = \frac{52 \text{ grains}}{120 \text{ grains}} = 43\%$$

Inferences, assuming Black's theory

- *Fixed air* comprises 40% of calcareous earth (since calcareous earth lost 40% of its weight when dissolved in acid).
- *Fixed air and water* together constitute 43% of calcareous earth (since calcareous earth lost 43% of its weight when calcined.
- *Water* constitutes 3% of calcareous earth ($43 - 40 = 3$).

Questions

1. According to Meyer's theory, what happens when calcareous earth is calcined? What is lime? Why is there a loss of weight?
2. What is Meyer's explanation for the result Marggraf obtained when he distilled calcareous earth?
3. State Meyer's explanation for the following:
   (a) Calcareous earth effervesces in acids.
   (b) Lime is soluble in water and calcareous earth is not.
   (c) A crust forms on lime water.
   (d) Lime makes alkalis caustic.
4. Describe two experiments of Black that, assuming his theory, determine the percentages of lime, air, and water in calcareous earth. What are these percentages and how are they inferred from these experiments?

References

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Patrick Maher.
The confirmation of Black's theory of lime.
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