AP 3050 Air Pollution

Air Pollution and Global Warming: History, Science, and Solutions

Chapter 1: History of Air Pollution

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By Mark Z. Jacobson
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Definitions

Air. A mixture of gases and particles, both made of atoms.

Atom. Nucleus containing 1-92 positively-charged protons and 0-146 zero-charged neutrons surrounded by 1-92+ negatively charged electrons in orbit around it.

Ion. Atom with a different number of protons from electrons.

Atomic mass. Average mass of protons plus neutrons in the nucleus of an atom.

Atomic number. Number of protons in an atomic nucleus.

Definitions

- **Element**. Single atom or substance composed of several atoms, each with the same atomic number.

- **Isotope**. Atoms of an element with a different number of neutrons in the nucleus (but same number of protons).

Definitions

- **Gas.** Individual atoms or molecules suspended in the air in the gas phase.
- **Particle**. Aggregate of atoms and/or molecules in the liquid and/or solid phase.
- **Aerosol**. Ensemble of solid, liquid, or mixed-phase particles suspended in air.
- **Aerosol particle**. A single liquid, solid, or mixed-phase particle among an ensemble of suspended particles.

Definitions

- **Hydrometeor**. Ensemble of solid, liquid, or mixed-phase particles containing primarily water.

- **Hydrometeor particle**. A single particle among an ensemble of particles containing primarily water.

Definition of Air Pollution

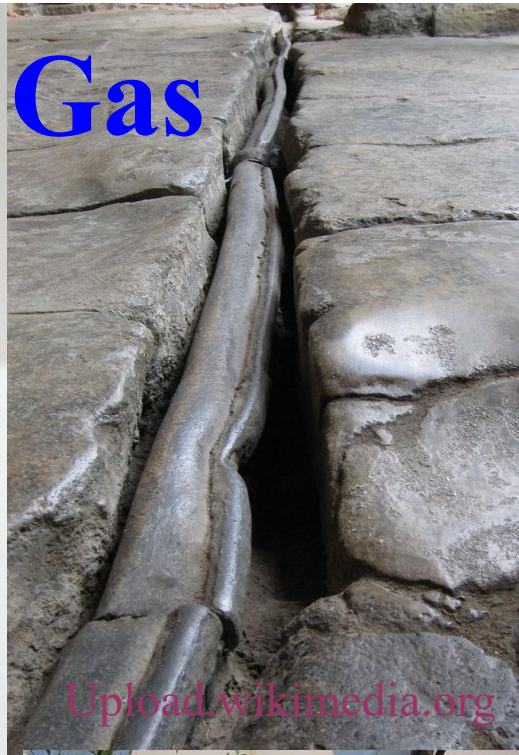
Buildup in the air of anthropogenically-emitted gases and/or aerosol particles in concentrations sufficiently high to cause damage to humans, plants, animals, other life forms, ecosystems, structures, or works of art.

Ancient world - 1690

- First identified: gold (Au), silver (Ag), Lead (pb), mercury (Hg), iron (Fe), copper (Cu), tin (Sn).
- Cultures including the Egyptians and Chaldeans were aware of these elements.
- Au: Sun, Ag: Moon, Pb: Saturn, Hg: Mercury, Fe: Mars, Cu: Venus, Sn: Jupiter.
- Pb, Hg and Fe are more related to air pollution.

Lead Ore, Roman Pipes, Gas

Img.alibaba.com



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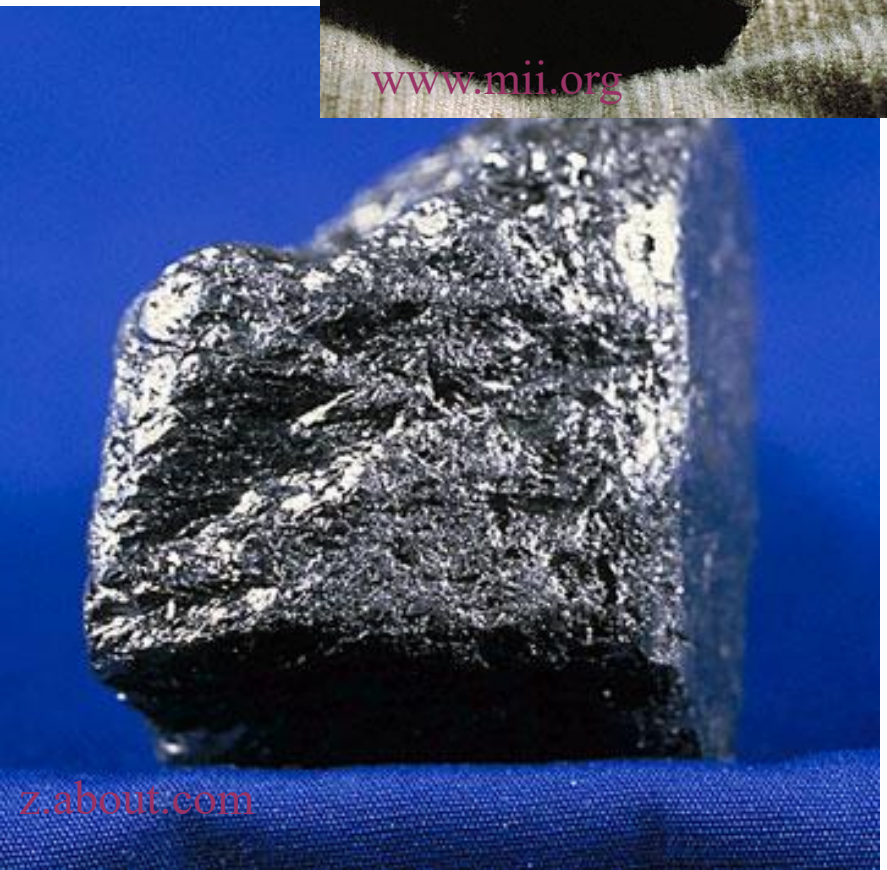
Iron Ore, Iron Smelter
Bamako, Mali During Dust Event

Sulfur, Kawah Ijen Volcano, Indonesia
Sodom & Gomorrah 1900 BC; John Martin c. 1850

Kawah Ijen Volcano sulfur mining

https://www.youtube.com/watch?v=W6TXLcQ6Z88

Carbon-Coal, Charcoal, Graphite, Uncut Diamonds



Sulfuric Acid From Alum (明礬)

Vincent de Beauvais

(1190-1264)

z.about.com

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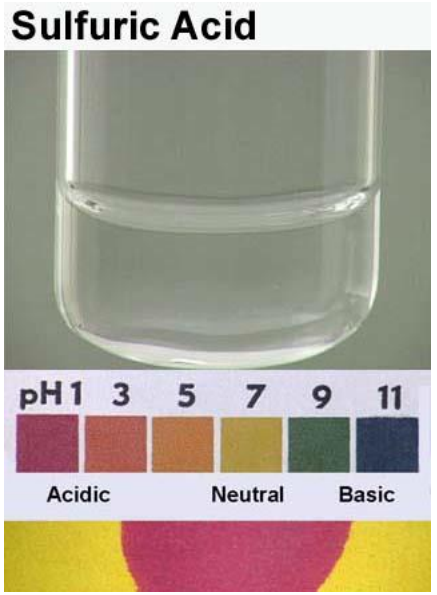

Genchem.chem.wisc.edu

Sulfuric Acid From Saltpetre & Sulfur

Andreas Libavius (1540-1616)

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University of Pennsylvania Library

Great Saltpetre Cave, Kentucky

Saltpetre
KNO_3

Sulfur

Water vapor

1450, German cardinal, philosopher, administrator, Nicolas of Cusa (Nicolas Cryfts) (1401-1464) described first hygrometer:

"If someone should hang a good deal of wool, tied together on one end of a large pair of scales, and should balance it with stones at the other end in a place where the air is temperate, it would be found that the weight of the wool would increase when the air became more humid, and decrease when the air tended to dryness."

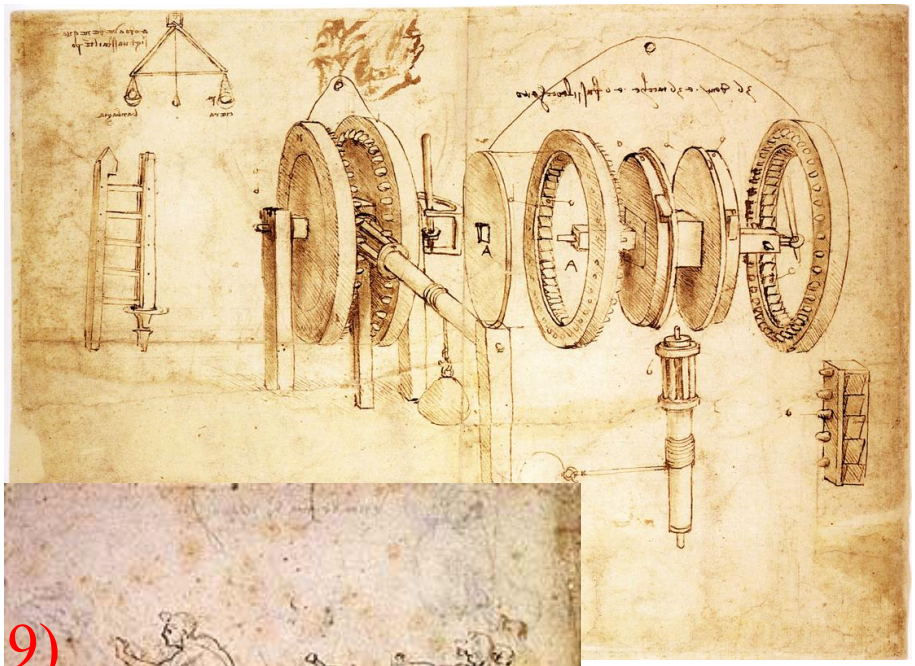
1481, Leonardo da Vinci (1452-1519) drew Cryft's hygrometer in his *Codex Atlanticus* **(大西洋古抄本),** using a sponge instead of wool. The purpose of the hygrometer was

"…to know the qualities and thickness of the air, and when it is going to rain."

1614. Santorio Santorre developed a hygrometer that measured water vapor by the contraction and elongation of cord or lyre strings.

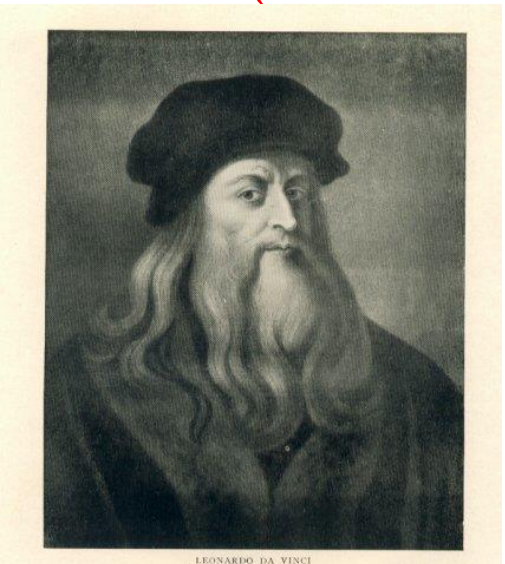
Water Vapor

Cryfts (1401-1464)



Toothed Gears
And Hygrometer
Codex Atlanticus
大西洋古抄本

DaVinci (1452-1519)



Study for the *Adoration of the Shepherds* and Hygrometer

Molecular Hydrogen

Produced by Ocean, soil bacteria and combustion

Sulfuric Acid → Zinc (Zn)

Paracelsus (1493-1541)

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Hydrogen vs. gasoline fire

Different Risk Between Hydrogen and Gasoline (Catherine E)

Iron ore

Fire-Air and Phlogiston (燃素)

Mayow (1643-1679)

An experiment of candle and animal in a vessel.

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Oxygen

Phlogiston Theory

Georg Stahl (1702). All combustion released phlogiston:

Metals + fire --> phlogiston + “calx” (residue；金屬灰)

Sulfur + fire --> pure phlogiston

Phosphorus + fire --> phlogiston + powder

Animal respiration --> pure phlogiston

In reality, during combustion, materials gain weight from oxygen:

$2Hg(s) + O_2(g) + \text{fire} \rightarrow 2HgO(s)$

$S(s) + O_2(g) + \text{fire} \rightarrow SO_2(g)$

$4P(s) + 5O_2(g) + \text{fire} \rightarrow P_4O_{10}(s)$

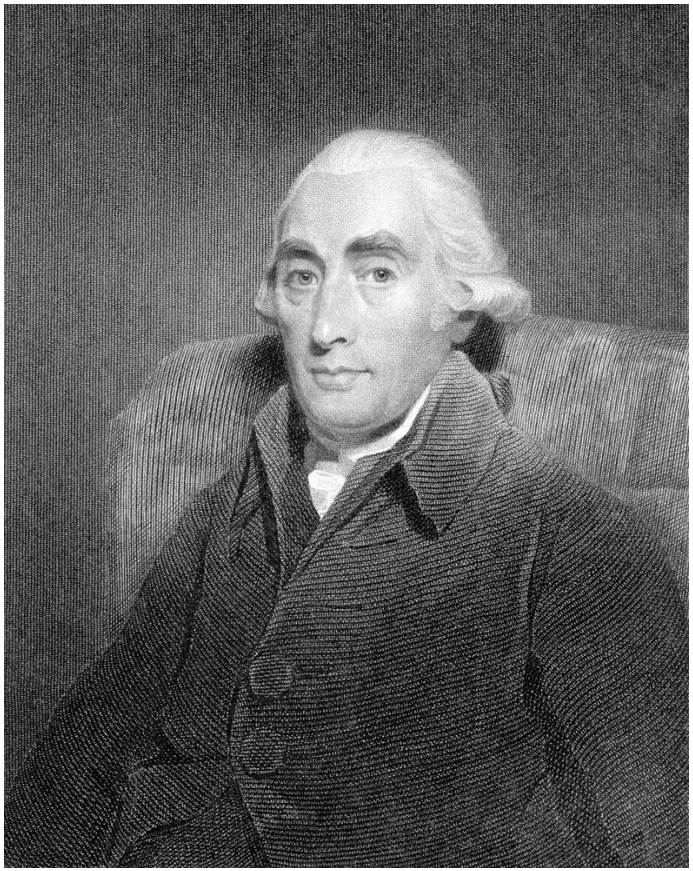
$C(s) + O_2(g) + \text{fire} \rightarrow CO_2(g)$

$CH_4(g) + O_2(g) + \text{fire} \rightarrow CO_2(g) + 2H_2O(g)$

Carbon Dioxide

Burning!
Burning!

Joseph Black (1728-1799)



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Magnesium carbonate $MgCO_3$

Calcium carbonate $CaCO_3$

Experiment to Produce $CO_2(g)$

Combine vinegar and baking soda

$CH_3COOH(aq) + NaHCO_3(s)$

--> $CH_3COO^- + H^+ + Na^+ + HCO_3^-$

--> $CH_3COO^- + Na^+ + H_2CO_3(aq)$

--> $CH_3COO^- + Na^+ + H_2O(aq) + CO_2(g)$

--> $CO_2(g)$ blows up balloon.

Daniel Rutherford (1749-1819)

Molecular nitrogen [N_2 (g)]
Removed O_2(g) from air by letting an animal breathe; removed CO_2(g) by

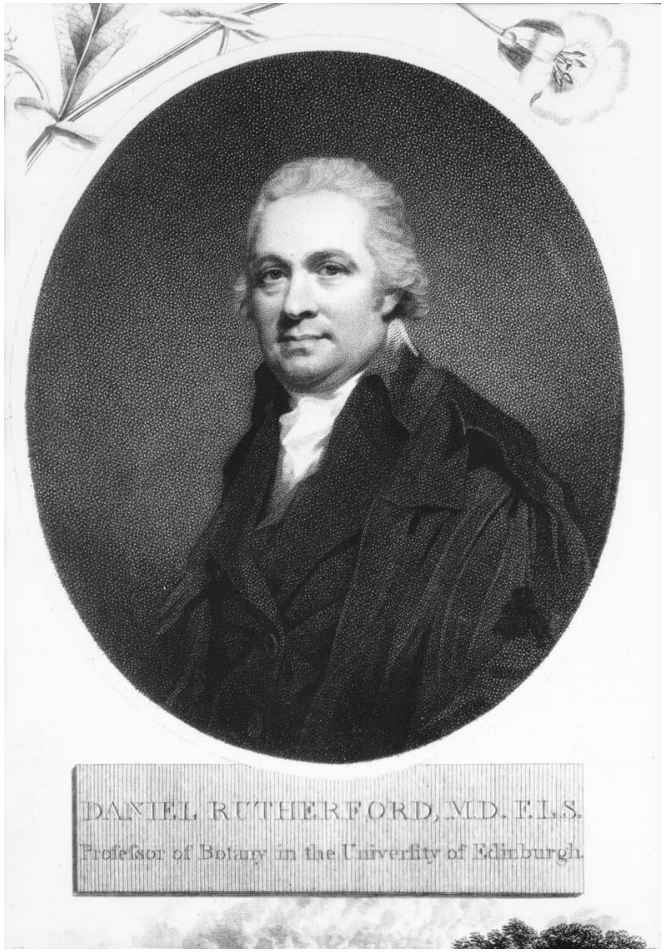
Burning wood

$CO_2(g)+2KOH(s) \rightarrow K_2CO_3(s) + H_2O(g)$

The residue could not sustain life --> "mephitic (noxious or poisonous) air" (1772).

Renamed "nitrogen" named in 1790 by Chaptal (1756-1832).

N_2(g) is tasteless, colorless, odorless



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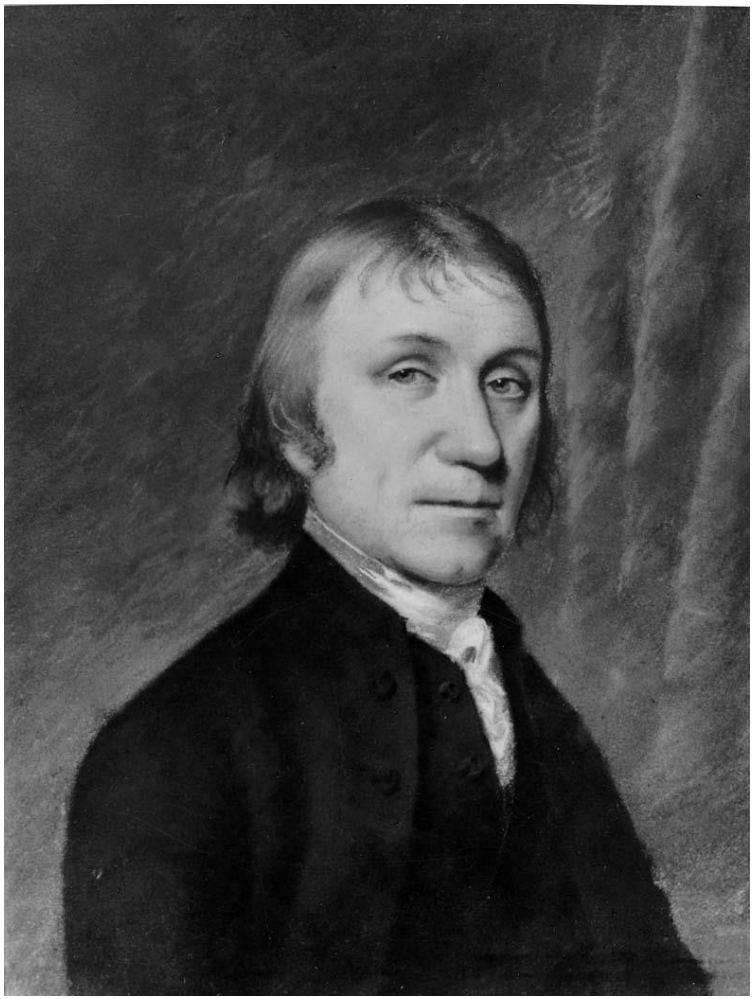
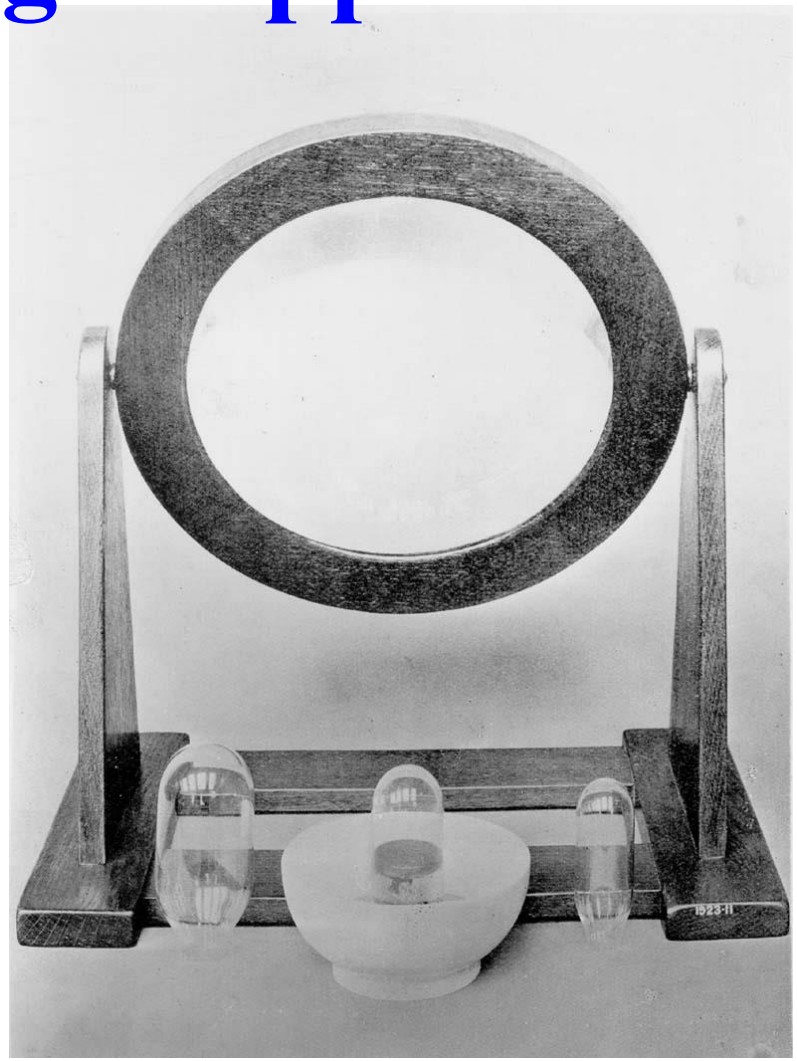
Reconstruction of Priestley's (1733-1804) oxygen apparatus





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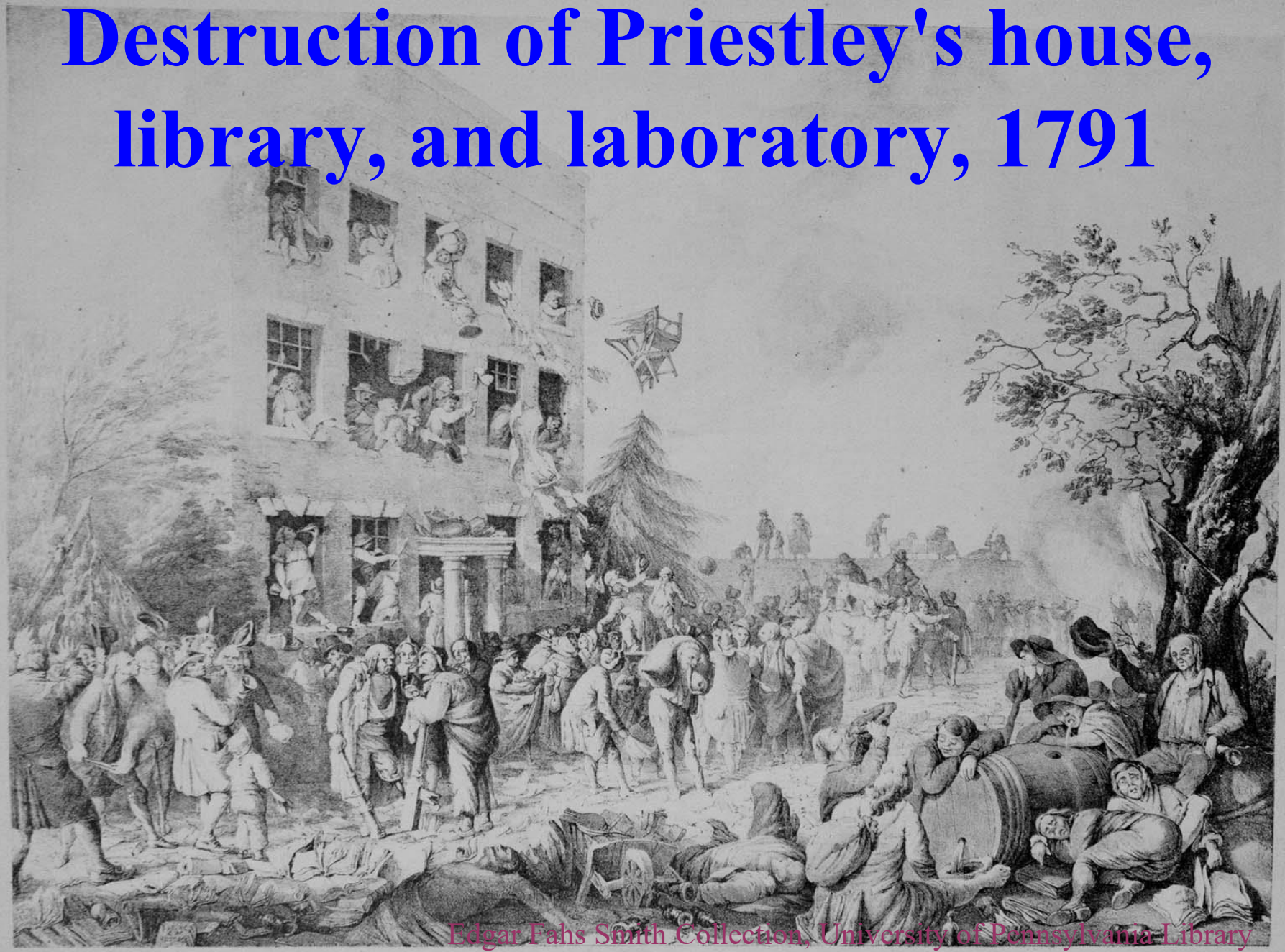
Destruction of Priestley's house, library, and laboratory, 1791



Christain F. Schönbein (1799-1868)- O_3

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Electrolysis

Assignment 2
Due 1 pm, 13 March

- 就以下物質，探討其跟大氣污染的關聯性、發現歷史、物理化學特性、實務應用….等
- (1) 汞 Hg　　(2) 砷 As
- (3) 銅 Cu　　(4) 鐵 Fe
- (5) 硫 S

On 13 March, each of you presents the results.