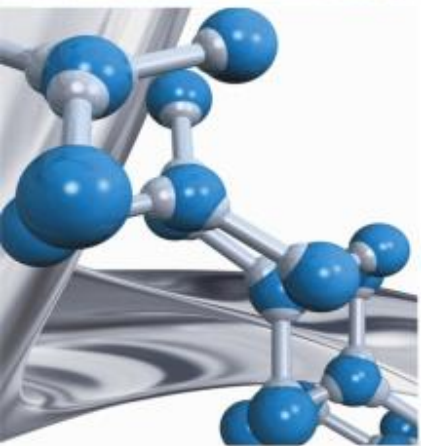
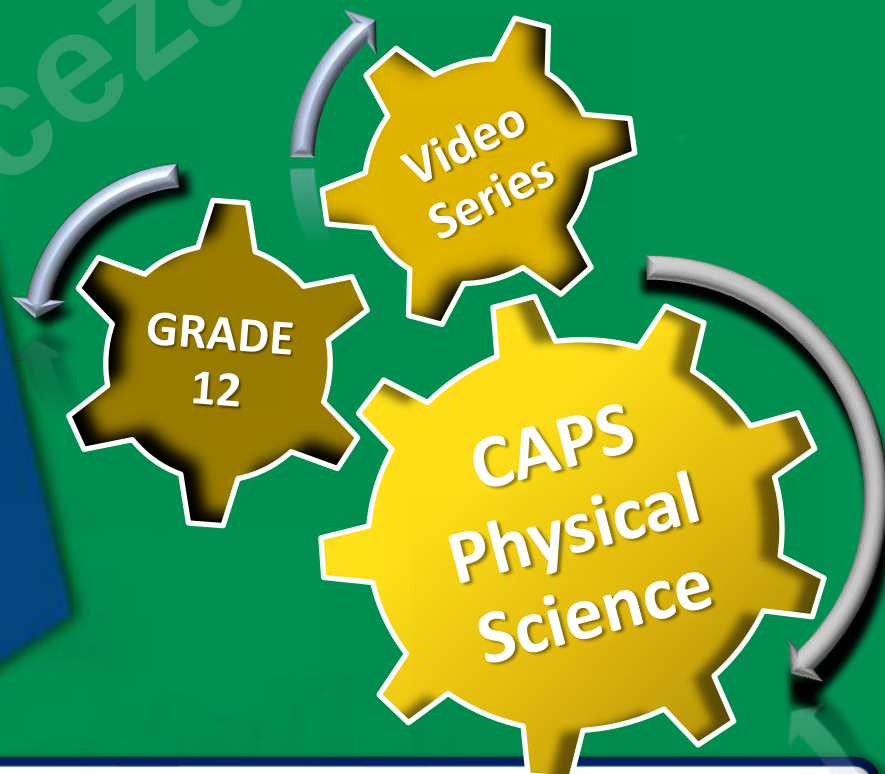




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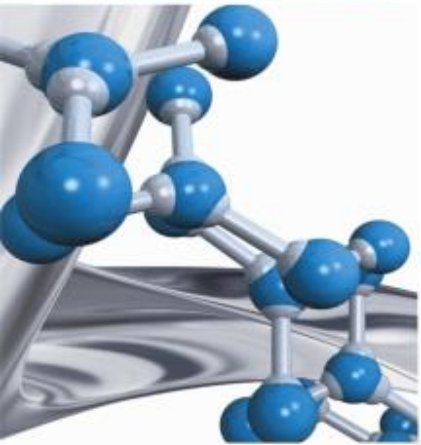
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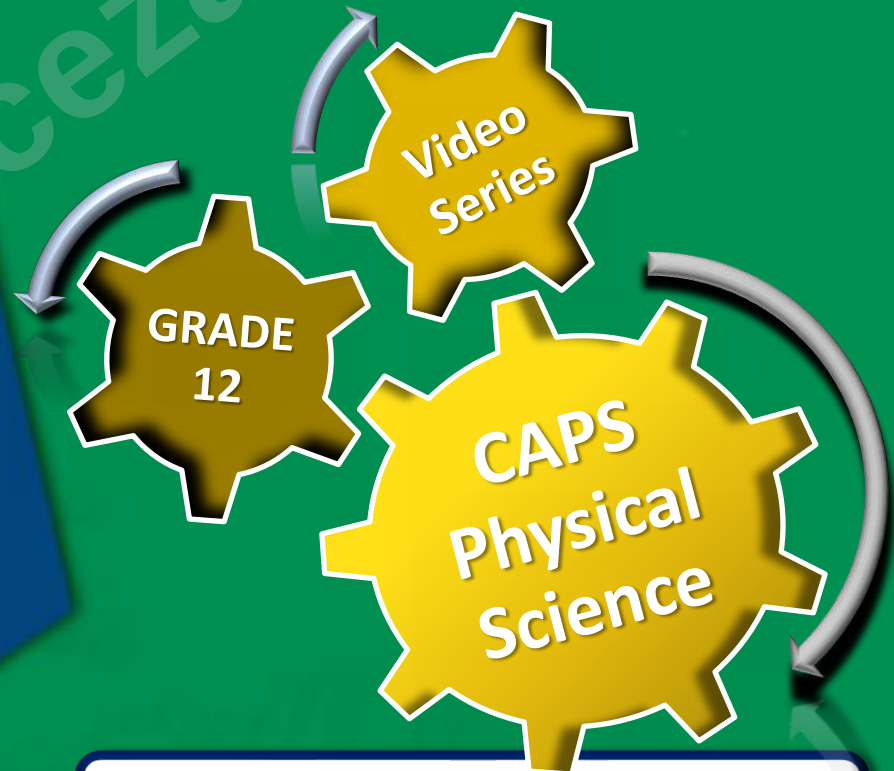
MATTER & MATERIALS

Lesson 5: Emission Spectra

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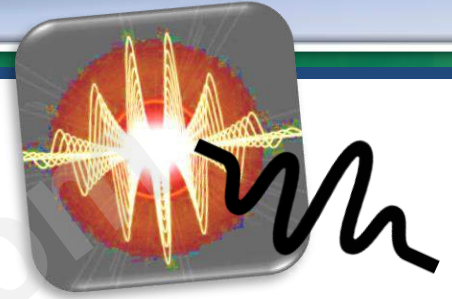
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Optical Phenomena

Lesson Objectives

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ATOMIC SPECTRA:

Every atom consists of a nucleus with a number of electrons at various energy levels orbiting around the nucleus.

- Absorbing energy, electrons can be excited to higher, but unstable energy states ..
- When the electrons fall back to a lower, more stable level, energy is released. The frequency (and hence colour) of the energy / light released depends on the interval between the various energy levels.
- The transition energy can also be absorbed by the atoms of the material, increasing the internal energy of the medium.

In this lesson we are going to focus on the following

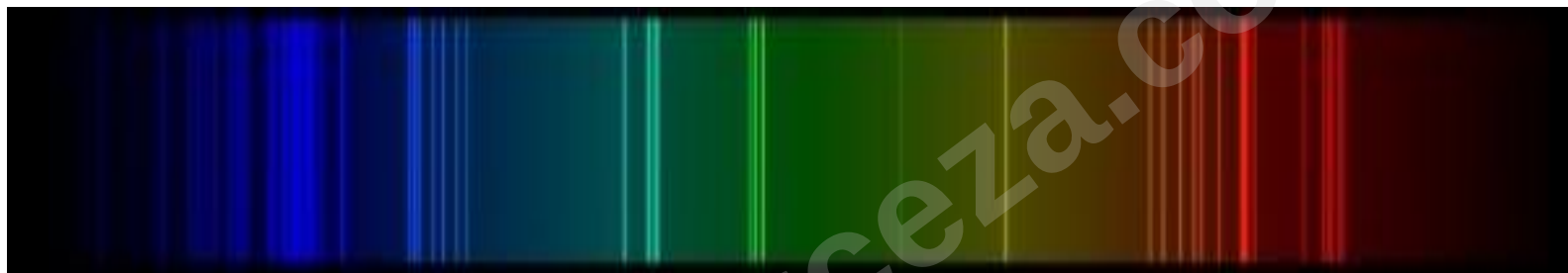
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phenomenon: **Every element has a unique atomic spectrum!**

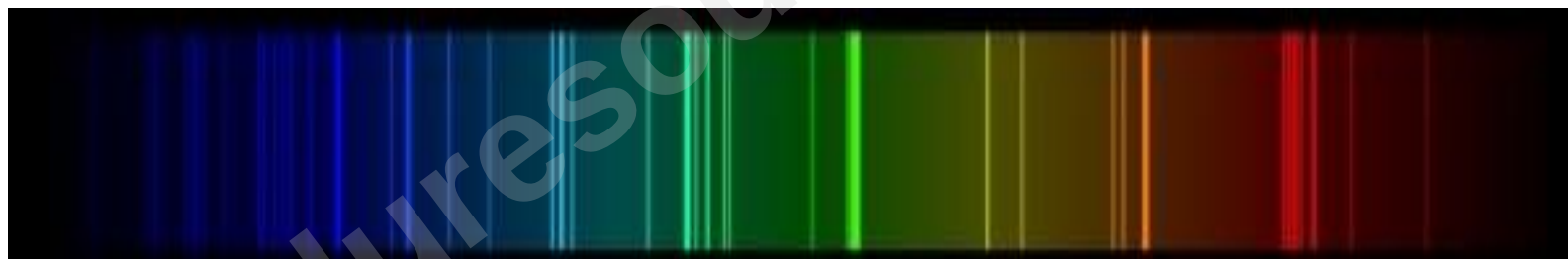
Emission Spectra

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Consider the Emission Spectra of Sodium and Calcium:



sodium



calcium

Sodium has a broad emission in the orange range of the spectrum.

Sodium vapour is used in street lamps for its characteristic orange glow.

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“Hot” Gas

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When gas is **heated** the heat can also be used to excite electrons to higher states.

This heated gas then emits light and when this light is passed through a prism it forms a spectrum.

An **ATOMIC EMISSION SPECTRUM** is formed when **certain frequencies of electromagnetic radiation are emitted** due to an atom's electrons making a transition from a high-energy state to a lower energy state.

This spectrum is **unique** for every element.

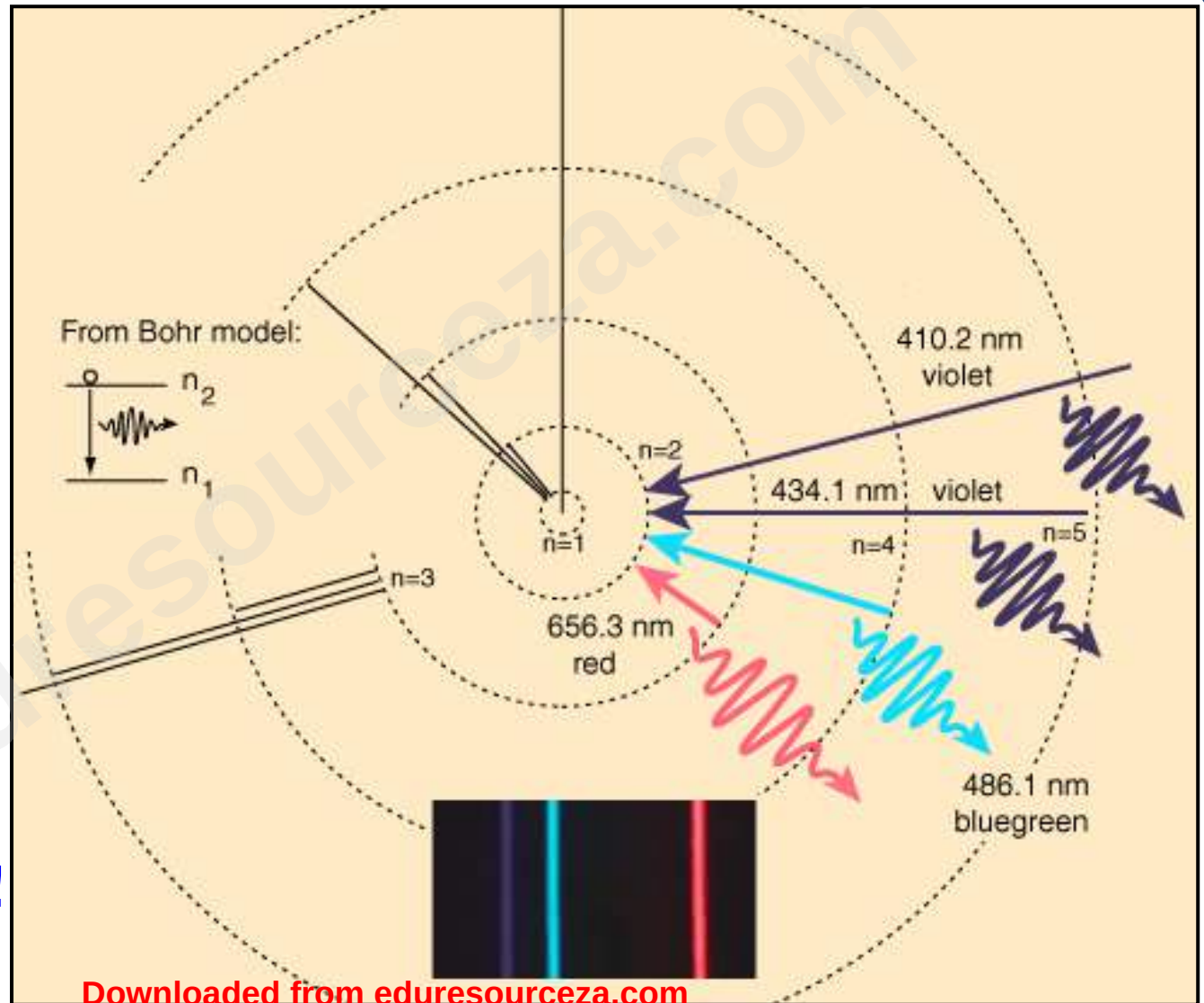
- Any element can be vapourized and excited to produce its own unique pattern of frequencies.

This type of spectrum is characterised by the fact that **only a few frequencies of light are emitted**.

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Transitions and Spectral Lines

Here we see the transition of electrons in the atom of a certain element and the corresponding photons emitted. Note the corresponding **SPECTRAL LINES!**



“Cold” Gas

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When white light is passed through a cold gas vapour, only specific frequencies of the light are absorbed.

The light that is transmitted by the gas is then passed through a diffraction grating or a prism.

The resulting

(a)

An **ATOMIC ABSORPTION SPECTRUM** is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, are absorbed.

Every element has a unique **ABSORPTION SPECTRUM**.

Diffraction Grating: A glass slide consisting of a large number of evenly spaced parallel slits.

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Amazing Lines

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What is so amazing, is that the frequencies absorbed by the cold gas is exactly the ones emitted by the hot gas!

Absorption Lines



Emission Lines



The amount of energy required to move electrons to higher orbitals (absorption) equals the amount of energy they release when returning (emission).

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Identification of Elements

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Class Exercise 1/1

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1. Name three different types of spectra and explain how each type is formed.

CONTINUOUS SPECTRUM: White light diffracted through a prism.

LINE EMISSION SPECTRUM: The light emitted by a hot gas sent through a prism.

LINE ABSORPTION SPECTRUM: Light emitted by a cold gas observed through a prism or diffraction grating when white light is sent through the cold gas.

2. The emission and absorption spectra of an element show different wavelengths. Is this statement true or false? Explain.

It is false. Frequencies of missing lines correspond to line emission spectra of their respective elements.

Reason: the same frequencies of light that they emit when heated are absorbed when light passes through them.

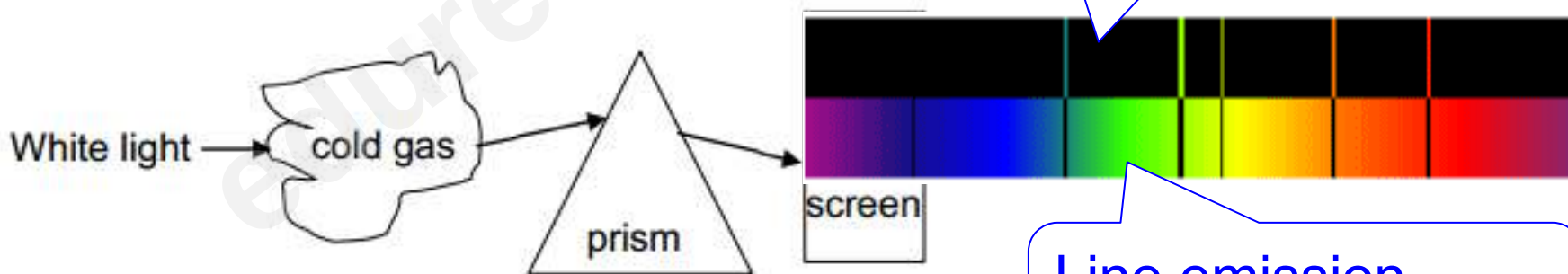
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Class Exercise 1/2

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3. Light spectra help to identify elements. White light is passed through a cold gas then then through a prism as shown in the sketch. What **type of spectrum** is observed on the screen?

- ☒ A line absorption spectrum
- ☐ B line emission spectrum
- ☐ C continuous absorption spectrum
- ☐ D continuous emission spectrum



Line emission spectrum (hot gas)

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Class Exercise 1/3

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4. How are the lines in an atomic spectrum related to the different energy levels in an atom?

When electrons fall back from higher to lower energy levels, certain quantities of energy is emitted, leading to light of specific frequency (with the energy of the emitted photon = ΔE between energy bands).

5. Explain why line spectra produced by hydrogen gas-discharge tubes are different from those produced by helium gas-discharge tubes.

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Class Exercise 1/4

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6. An astronomer is looking at the spectrum of a galaxy and finds that it has an oxygen spectral line of 525 nm, while the laboratory value is measured at 513 nm. Calculate how fast the galaxy would be moving relative to Earth.
- 6.1. Explain whether the galaxy is moving toward or away from Earth and how you know.

$$525 \text{ nm} > 513 \text{ nm}.$$

Longer λ (smaller f)

$\Rightarrow$ spectral line shifted towards red region of spectrum.

The galaxy is moving away from Earth and light from the galaxy is red-shifted because of the Doppler-effect.

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Class Exercise 1/5

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6.2. How fast is a galaxy moving relative to Earth if a hydrogen spectral line of 486 nm is red-shifted to 491 nm?

$$f_s = \frac{c}{\lambda} = \frac{3 \times 10^8}{486 \times 10^{-9}} \\ = 6,17 \times 10^{14} \text{ Hz}$$

$$f_L = \frac{c}{\lambda} = \frac{3 \times 10^8}{491 \times 10^{-9}} \\ = 6,11 \times 10^{14} \text{ Hz}$$

$$f_L = \frac{v \pm v_L}{v \pm v_s} \cdot f_s$$

$$6,11 \times 10^{14} = \frac{340}{340 + v_s} \cdot 6,17 \times 10^{14}$$

$$v_s = 3,34 \text{ m} \cdot \text{s}^{-1} \text{ away from Earth.}$$

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Every element has a unique **ATOMIC SPECTRUM**!

An **ATOMIC EMISSION SPECTRUM** is formed when **certain frequencies of electromagnetic radiation are emitted** due to an atom's electrons making a transition from a high-energy state to a lower energy state.

Emission Lines



An **ATOMIC ABSORPTION SPECTRUM** is formed when **certain frequencies of electromagnetic radiation** that passes through a medium, e.g. a cold gas, **are absorbed**.

Absorption Lines



Key Concepts 2

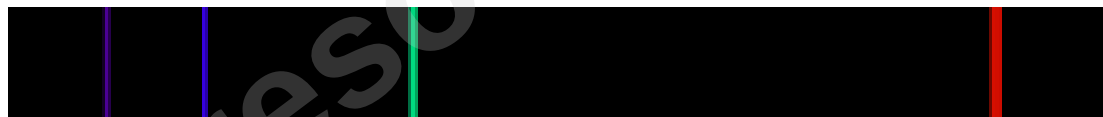
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Frequencies of missing lines correspond to line emission spectra of their respective elements.

Absorption Lines



Emission Lines



Reason: the same frequencies of light that they emit when heated are absorbed when light passes through them.

Line spectra can be used to **identify** an unknown element.

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Diffraction Grating: A glass slide consisting of a large number of evenly spaced parallel slits.

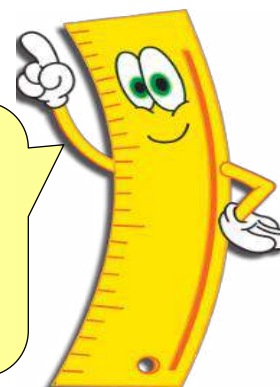
What Next?

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- **Memorise** the various definitions
- **Review** the exercises you had difficulty with ...
- and do some **additional exercise** ...
 - as given in your **workbooks** that accompany this video series or from your school textbook

Continue your learning by watching the
next video lesson in this series:

Lesson 1: Redox Reactions



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PhiniseD