Atomic Spectra

Created	@February 28, 2023 12:42 PM
Class	Chemistry
Type	
Materials	
Reviewed	☐

Differences in Discrete Energy Levels

Key Points:

1. **Unique Spectra**: As the discrete energy levels for atoms are fixed and unique to each atom, the discrete energy level differences are also fixed and unique to each element.
2. Therefore, each element has different and unique emission and absorption spectra as the range of frequencies of light emitted are based on this unique set of discrete energy level differences

Atomic Emission Spectra: used to identify elements in mixtures of high concentration

1. The substance is vaporised, and put into a discharge tube
2. An electric discharge is passed through the tube. Electrons in the discharge excite other electrons by transferring kinetic energy during collision, then deflecting and losing energy
3. The electrons are **excited to a higher energy state** (as it has experienced an increase in energy exactly equal to E2 - E1)
4. Since they are unstable in their excited state, they will **transition** down to their **ground state**, and release energy in the form of radiation that has energy exactly equal to E2 - E1
5. Since **multiple transitions can occur within an atom**, a unique set of photons with a specific wavelength each is produced; thus when these emissions are

captured an analysed in a line spectrometer; we only see specific light present

6. This produces a single stream of radiation, as all the wavelengths are travelling in the same direction. When the radiation is passed through a prism, the different frequencies/wavelengths are **separated** from each other, and are projected onto a black spectrum
7. It takes the form of coloured lines on a black background
8. Because all elements have a **unique spectra**, we can identify the element based on this

Atomic Absorption Spectra: used to identify elements in mixtures of high concentration

1. White light (light of all frequencies) is passed through a substance in cool gas form
2. The substance's electrons absorb the photons and become **excited** (increase in energy exactly equal to E2-E1)
3. The electrons then transition back down to their **ground state**, as they are unstable in their normal state
4. However, the energy emitted (equal to E2-E1) d**oes not travel parallel** to its original direction. Therefore, they will not reach the spectroscope, and are **missing** from the spectrum
5. It takes the forms of black lines on the colour spectrum
6. Because all atoms have a **unique spectra**, we can identify the element based on this

Flame Test: used to detect primary metal ions

1. Sample of the element/compound is introduced to a colourless, non-luminous flame
2. As the substance is heated, its **electrons become excited**, as they gain energy, and transition to a higher energy state

3. The electrons are unstable in this state, so they quickly transition to their ground state. When this happens, it emits photons with energy equal to the difference in energy levels which correspond to specific wavelengths
4. Therefore, the **photons have specific wavelength**s. Higher energies mean smaller wavelengths, and vice versa. **Specific wavelengths** mean **specific colours** are **observed**
5. Since excited electrons can transition to their ground state in multiple stages, a set of different photons of different wavelengths can be emitted. Therefore, a **spectra of different wavelengths of light is noticed**
6. As most non-metals emit EMR outside the visible spectrum, we cannot use the flame test to identify non-metal atoms present. Most metals produce some EMR in the visible spectrum that can be used to identify them

What can it be used for?

1. Ionic salts: we can only use the flame test for simple ionic solids and metals because when heated, the metal ions and the anions separate and the metal ion produces emission that is within the visible spectrum

What can't it be used for?

1. Complex molecules:
    a. These molecules have a large number of energy levels that can overlap to produce new energy levels, and so, excitation and de-excitation within these molecules produce a large variety of EMR and so their emission is not characteristic
    b. Large majority produce EMR that is outside the visible spectrum, so it cannot be observed

Disadvantages

1. The salt's metal cation may not be excited by the relatively low temperature of the flame, e.g., magnesium
2. Salt may not be completely excited, meaning only a part of the emission spectra is emitted, leading to a different colour being observed
3. If the material is a non-metal (e.g. ionic compound), it may not be (fully?) excited at low temperatures or may produce EMR outside the visible spectrum
4. Ethanol and oxygen may get involved, changing the observed colour (orange flame)

5. Some elements have (very?) similar colours; this makes it difficult to distinguish between 2 different elements