Spectroscopy

Spectroscopy is the study of the interaction of matter with **electromagnetic radiation**. Types of spectroscopy are:

Instrument	Radiation Used	Used For:
MRI (Magnetic Resonating Imaging)	Radiowaves	Image the body
Light microscopy	Visible light	Interact with cells
X-Rays	X-rays	image bones

Use the BEER-LAMBERT LAW

$$A = \varepsilon c l$$

A = **absorbance**. This is related to how much light can pass through a solution. Higher absorbance = less light gets through (a darker solution)

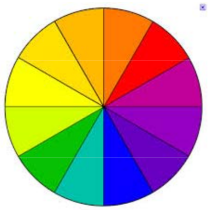
c = **concentration**. A more concentrated coloured solution will absorb more light

ε = **molar extinction coefficient**. For a given molecule, this is a constant.

l = **path length** – how far the light has to travel. If light has to travel through more solution, then more will be absorbed. **(cm)**

Understand the relationship between absorption and observed colour

White light is a combination of all colours. White materials absorb no visible light.



The colours of other objects are due to the particular wavelengths of light that they absorb.

A solid that absorbs a particular coloured light will reflect all other colours and appear the **COMPLIMENTARY OF THAT COLOUR** as per Newton's colour wheel.

E.G. **red** light and reflects all the other colours will appear **green**. A solid that absorbs **green** light is perceived by us as a **red** colour.

Transparent	allow all light to pass through [air, water]
Translucent	allow some light to pass through, rest is scattered [e.g. frosted glass, some plastics]
Opaque	No light passes through as it is completely absorbed or reflected [e.g. wood, stone, metals]

NAMING:

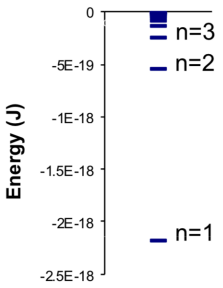
- The designation of a material as **coloured** or **colourless** is separate from these terms.
  - An **opaque**, colourless material will be white,
  - A **transparent**, colourless material will be clear.

Relate electronic absorbance and emission spectra to electronic structure AND

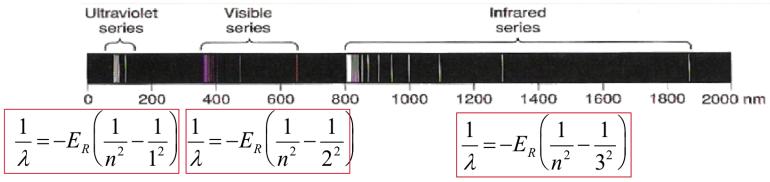
Calculate emission and absorption wavelengths from energy levels

- The **emission spectrum of hydrogen [SHOWN BELOW]** is composed of discrete wavelengths. [as shown using balmer equations]
- This shows that the gaps between energy levels are fixed, not discrete, and was early evidence that the energy of the electron in the atom is quantised.

These equations correspond to the movement of electrons between different energy levels in H



The UV and IR spectral lines are defined by similar equations



Use the Balmer equation to determine the wavelength of the electromagnetic waves based on the difference in energy levels [higher to lower or vice versa]

$$E_n = -E_R \frac{1}{n^2}$$

$$E_n = -E_R \frac{Z^2}{n^2}$$

**Note: These equations correspond to the movement of electrons between different energy levels in H*

Identify constraints on analysis by atomic absorption spectroscopy (AAS)

- The cathode lamp must be composed of the same element in order to accurately determine the concentration of the element in a given sample
- Since the light emitted from the cathode lamp can vary, standard(s) of known concentration must be run at the same time as the unknown. Often, a calibration curve is constructed, using a number of solutions of different concentration

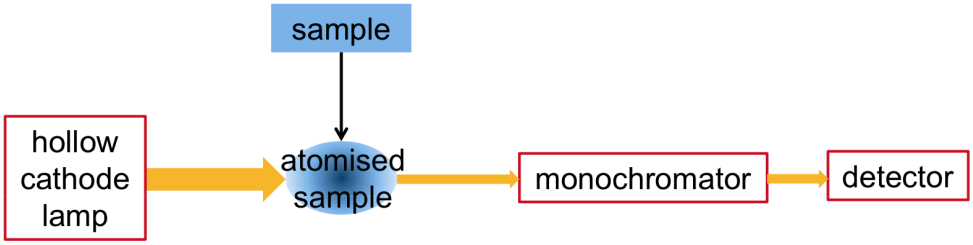
Describe the process of molecular spectroscopy

Compare and contrast atomic and molecular spectroscopy

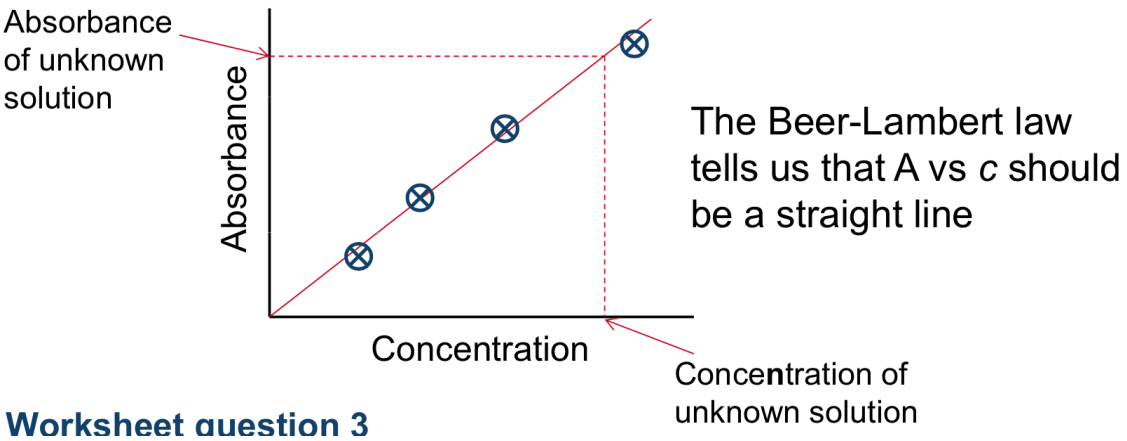
Similarities	**Differences**
Both use the same principle of: • **Beer-Lambert Law applies** • Molecules/Atoms absorb light at specific wavelengths according to their orbital energies	• Molecular spectroscopy does not require atoms to be atomised, as it measures the energy of electrons in molecules, not atoms

Describe how the hollow cathode lamp operates, and why it is central to sensitive AAS measurements

- Atomic absorption spectroscopy (AAS) uses the characteristic absorption of each element to determine concentrations of elements



1. The sample must be in atomic form, as sample bonding will change the energy levels
2. A hollow cathode lamp containing the atom of the element of interest will release light that will be specifically absorbed by that atom [at a distinct wavelength]
3. Some of the light will be absorbed by the atomised sample. The amount of absorbance is proportional to the concentration of the element in the sample.
4. The monochromator ensures that only the light of interest is measured, and the detector measures the absorbance. The absorbance value is fed to a computer to give the concentration of element in sample using a calibration curve.



Worksheet question 3