A neon installation on the side of a barn in Denmark

Lab 11: Atomic Spectra

Introduction

Why do neon lights glow? That, and why do they glow in different colors? First the glow: a neon tube is sealed and contains atoms of gas (neon, or maybe something else–more on that in a minute). When a voltage is applied, the tube begins to glow: flip the switch, the light comes on. The gas is energized by the voltage: all the neon atoms are the same, which means that the electrons of all the atoms exist in orbits with the same energy levels. Whatever precise amount of energy it takes to move an electron from one orbit to another, it's the same for all the neon atoms. So what you are seeing as the glow is electrons jumping from one energy level to another. As they fall back down to their original orbits, they emit an exact amount of energy in the form of a photon. When the millions of atoms in the tube all do this at the same time, you see the glow.

Now about the color. We know that the orbits correspond to precise energy quanta. But the quantum of energy is different for electrons belonging to different types of atoms. It does not take the same amount of energy to move an electron from one orbit to another in a hydrogen atom as it does to move between orbits in a neon atom. Different energy, different color. Neon glows strongly red, but mercury glows strongly blue. So it's not always actual neon in the neon light; it may be argon (with mercury particles), helium (yellow-gold) or even CO_2 (bright white).

Objectives

- View emission–line spectra of various elements
- Identify elements based on the pattern of emission lines
- Associate wavelengths of visible light with color
- Correlate the color of emitted light to the temperature of an object

Equipment

- Handheld spectroscope
- Gas–filled lamps

Procedure

- Point the slit of the spectroscope directly at the gas–filled lamp
- View the emission lines that appear, and record their color and wavelength
- Note the color–code identification band on the lamp (the color of the paint band does not match the color of the emission)
- Repeat for the remaining lamps

If you are not seeing lines, have your instructor check that the spectroscope is in alignment with the lamp.

Data & Analysis

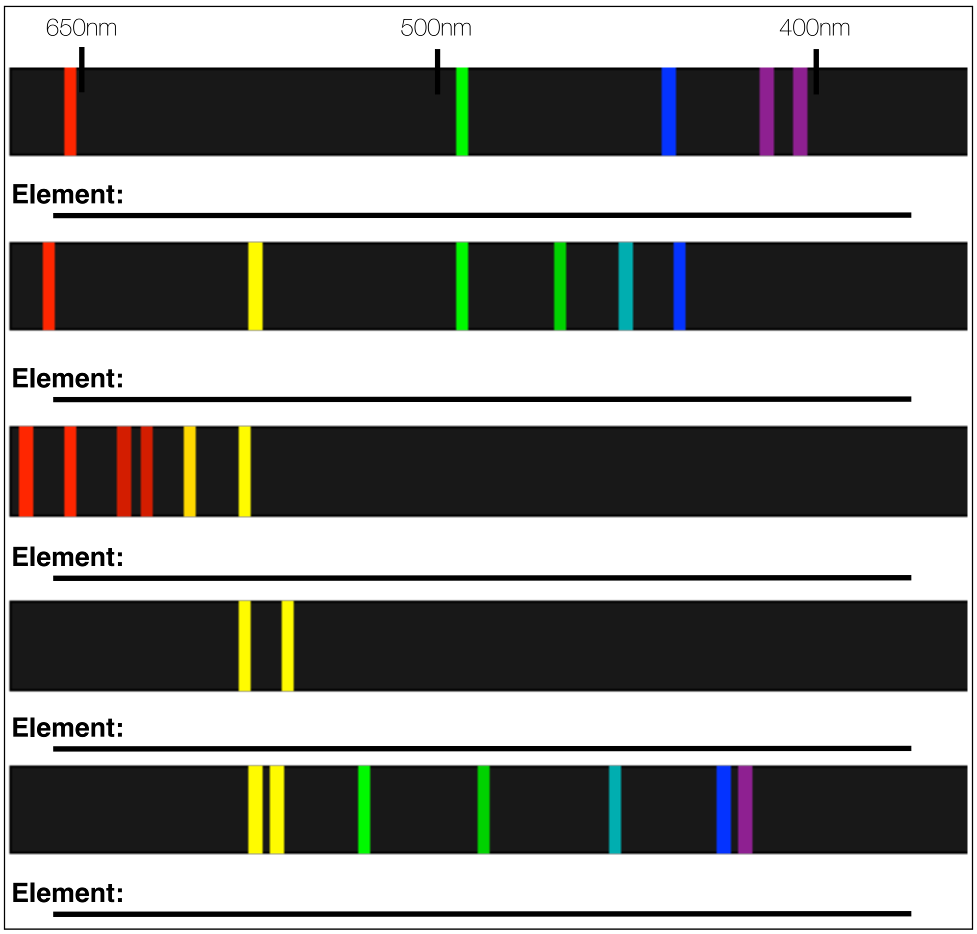
Make a table of the lamps you have viewed, and use it to identify the vapor in each lamp. You will need more rows for more lamps, and more columns for more observed emission lines than shown below. Each of the lamps contains a unique element. If the color band is different, so are the contents of the tube. The tube with the black band does not have the same vapor inside as the tube with the pink (or green, or any other color) band.

Tube	Observed Emission Line Wavelength (top) and Color (bottom)								Vapor ID
Example	460	496	609	670					lithium
	blue	blue	yellow	red					
1									
2									
3									
4									
5									
etc...									

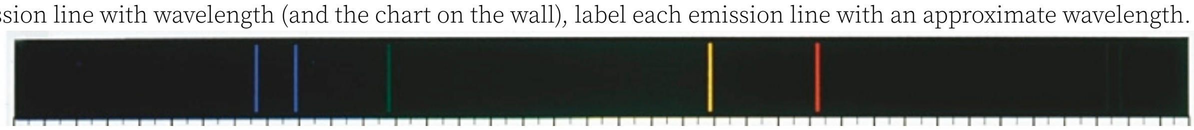
Use the table shown below to complete your identification of the lamps:

ELEMENT	STRONGEST EMISSION LINES: WAVELENGTHS IN nm											
HYDROGEN	410	434	486	656								
HELIUM	447	471	492	502	588	668	707					
NEON	540	585	587	588	594	597	598	599	603	607	610	640	651
MERCURY	405	435	513	546	577	579	615						
ARGON	416	420	428	435	466	473	476	481	488	642	697	707	715
KRYPTON	427	432	436	438	447	458	462	463	466	474	477	557	587
SODIUM	570	589	615										

1. Shown below in color are the emission spectra for five of the gases in the tubes you have examined. Because line strengths vary (and this is not shown on the figure), you may not have seen every line shown. You should, however, be able to recognize the patterns and identify each of the spectra with the correct element.



2. The emission spectrum for cadmium (Cd) is shown below in color. Using your table that correlates the color of the emission line with wavelength (and the chart on the wall), label each emission line with an approximate wavelength.

Cd 

3. The temperature (measured in Kelvins) of an object can be determined by noting the wavelength of its strongest emission (brightest color):

$$T = \frac{3 \times 10^6}{\lambda_{max}}$$

with λ_{max} measured in nm.

Find the temperature of

A) a red star with λ_{max} = 650nm.

B) a blue star with λ_{max} = 425nm.

C) a block of ice, with λ_{max} = $1.5\text{x}10^4$nm.