In [1]:
```python
from math import pi, exp
import numpy as np
import matplotlib.pyplot as plt
```

Task 2: Astrophysical Absorption Line Exercise

Next task is to generate a spectrum of light after it has passed through a slab of gas, and investigate the Lyman α absorption line of hydrogen. The part below shows how you can calculate a spectrum and the necessary information to complete the 3 subtasks.

Providing constant features

In [2]:
```python
# gas slab properties
nH = 0.1
x = 0.1
# hydrogen properties
v0 = 2.46607e15
L = 6.265e8
f = 0.4164
g0 = 2.0
Z = 2.0
# physical constants
me = 9.11e-28
c = 3.00e10
e = 4.80e-10
```

Methods for calculations

In [3]:
```python
def calculate_absorption_coeff(v, v0):
    first = (e ** 2 * f  * nH) / (4 * pi * me * c)
    second = ((1 - x) * g0) / (Z)
    third = (L) / ((v - v0) ** 2 + (L / 4 * pi) ** 2)

    absorption_coeff = first * second * third
    return absorption_coeff
```

In [4]:
```python
def calculate_intensity(d, wavelength, v0):
    # using v = c / wavelength formula
    v = c / wavelength
    # calculating absorption coefficent
    absorption_coeff = calculate_absorption_coeff(v, v0)
    # calculate intensity with absorption coefficient
    intensity = exp(-absorption_coeff * d)
    return intensity
```

Method for generating and plotting spectrum

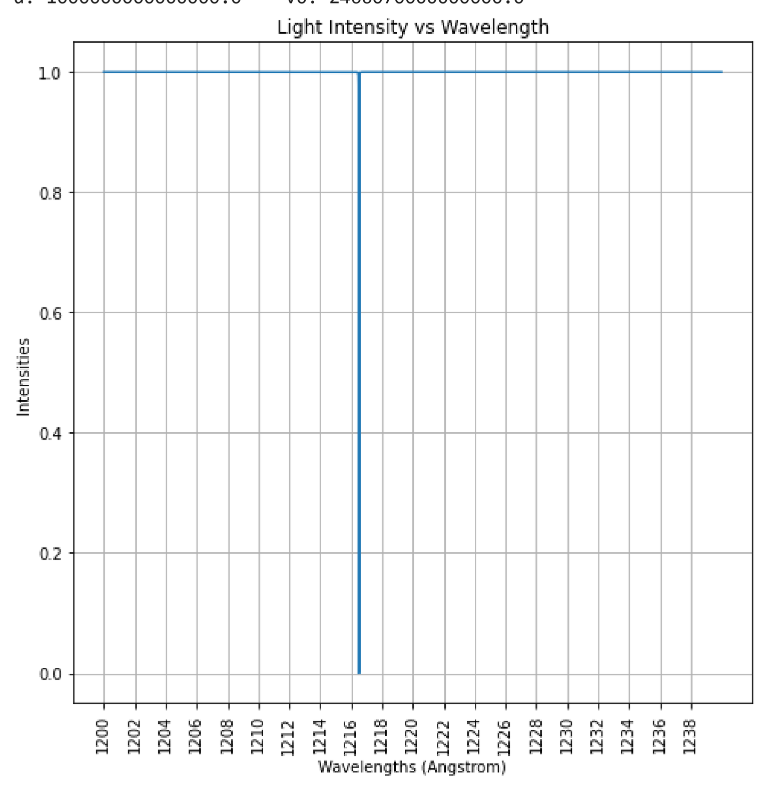
In [5]:
```python
# Reference: https://en.wikipedia.org/wiki/Lyman-alpha_line
# I have read that page and decided to pick wavelength start in 1200
def plot_spectrum(d, v0, wavelength_start=1200, wavelength_end=1240, num=100000):
    # generate wavelengths with np.linspace
    wavelengths = np.linspace(wavelength_start, wavelength_end, num)
    # store the intensities that we're going to calculate
    intensities = []
    # calculate intensities for certain wavelength
    for wavelength in wavelengths:
        # we're going to use  wavelength / 10 ** 8 because
        # we want to represent our wavelength in Angstrom.
        intensities.append(calculate_intensity(d, wavelength / 10 ** 8, v0))

    # plotting
    fig, ax = plt.subplots(figsize=(8, 8))
    ax.plot(wavelengths, intensities)
    plt.title("Light Intensity vs Wavelength")
    plt.xlabel("Wavelengths (Angstrom)")
    plt.xticks(np.arange(wavelength_start, wavelength_end, 2), rotation=90)
    plt.ylabel("Intensities")
    plt.grid()

    # find minimum intensity of plotting
    min_intesity = min(intensities)
    index_min_intesity = intensities.index(min_intesity)
    # find wavelength that created minimum intensity
    min_intensity_wavelength = wavelengths[index_min_intesity]

    # Print-out some information.
    print("Minimum intensity: {0}".format(min_intesity))
    print("Minimum insensity's wavelength: {0}".format(min_intensity_wavelength))
    print("d: {0} \t v0: {1}".format(d, v0))
```

Subtask 2.1

We need to generate spectrum with:
d equals $10^{14}, 10^{18}, 10^{21}$ and
v0 equals $2.46607 * 10^{15}$

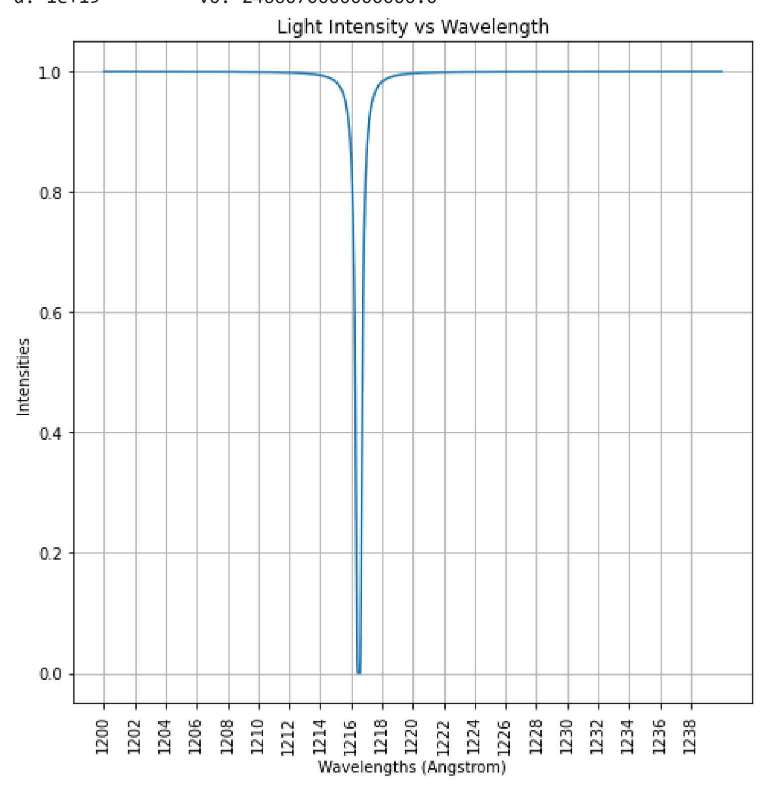
In [6]:
```python
d_list = [10e14, 10e18, 10e21]
plot_spectrum(d_list[0], v0)
```

```
Minimum intensity: 6.673493654441234e-26
Minimum insensity's wavelength: 1216.510565105651
d: 1000000000000000.0    v0: 2466070000000000.0
```



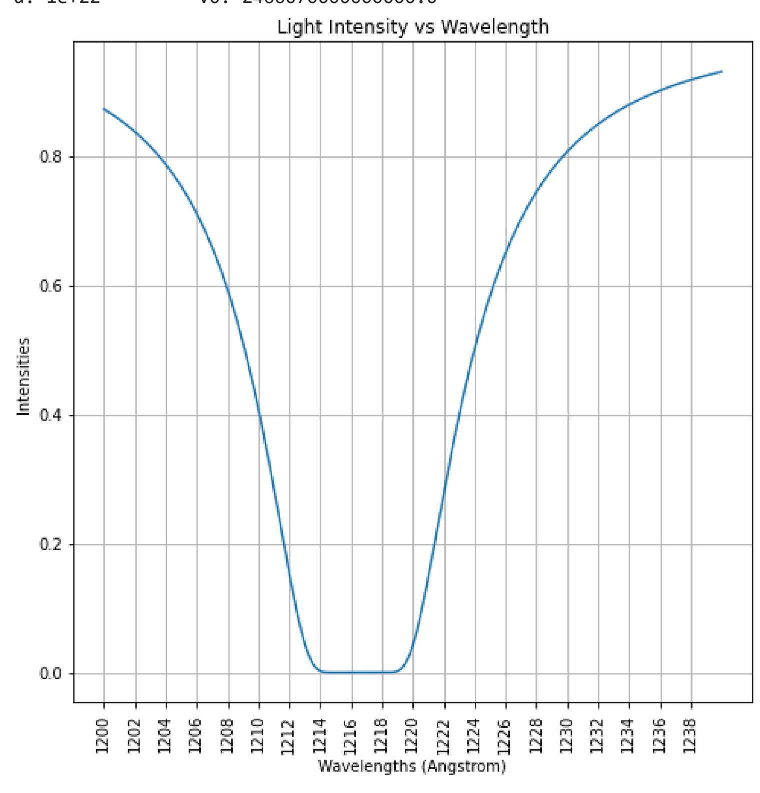
In [7]:
```python
plot_spectrum(d_list[1], v0)
```

```
Minimum intensity: 0.0
Minimum insensity's wavelength: 1216.5033650336504
d: 1e+19         v0: 2466070000000000.0
```



In [8]:
```python
plot_spectrum(d_list[2], v0)
```

```
Minimum intensity: 0.0
Minimum insensity's wavelength: 1216.2837628376283
d: 1e+22         v0: 2466070000000000.0
```

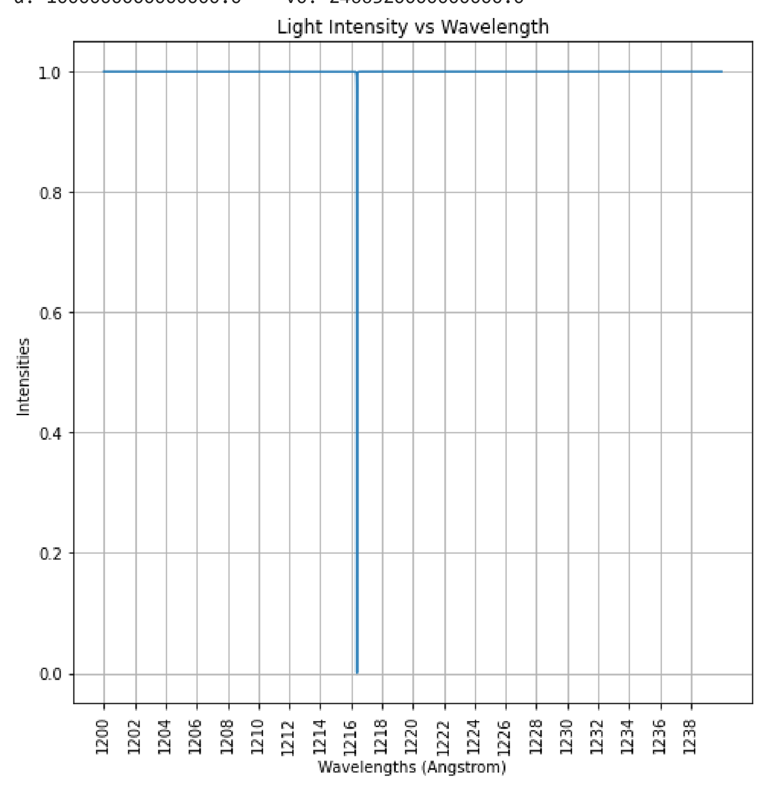


Subtask 2.2

We need to generate spectrum with:
d equals $10^{14}, 10^{18}, 10^{21}$ and
v0 equals $2.46632 * 10^{15}$

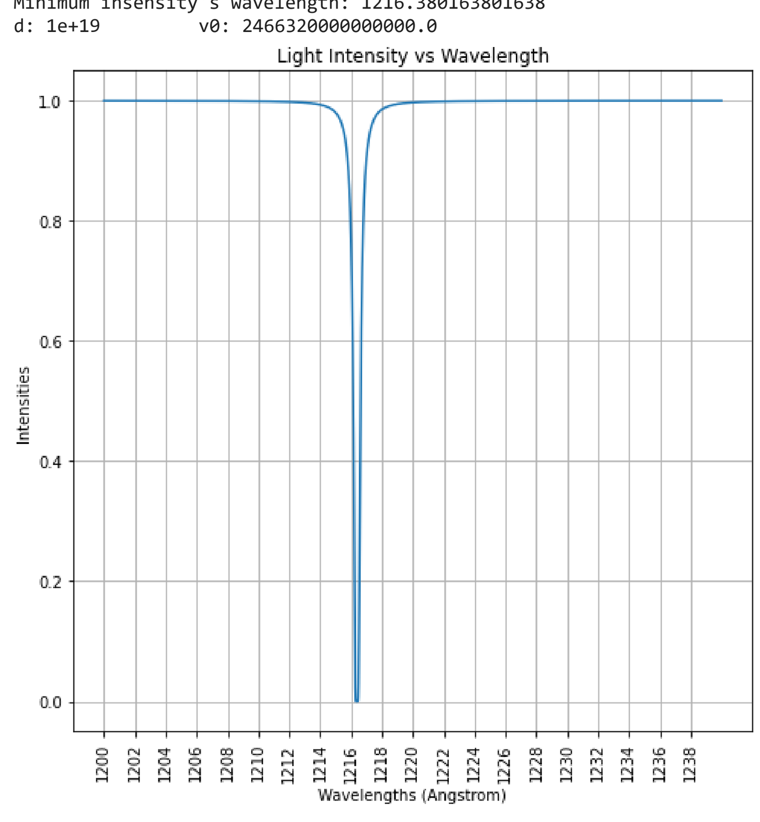
In [9]:
```python
v0_new = 2.46632e15
plot_spectrum(d_list[0], v0_new)
```

```
Minimum intensity: 7.887566410202593e-18
Minimum insensity's wavelength: 1216.3873638736388
d: 1000000000000000.0    v0: 2466320000000000.0
```



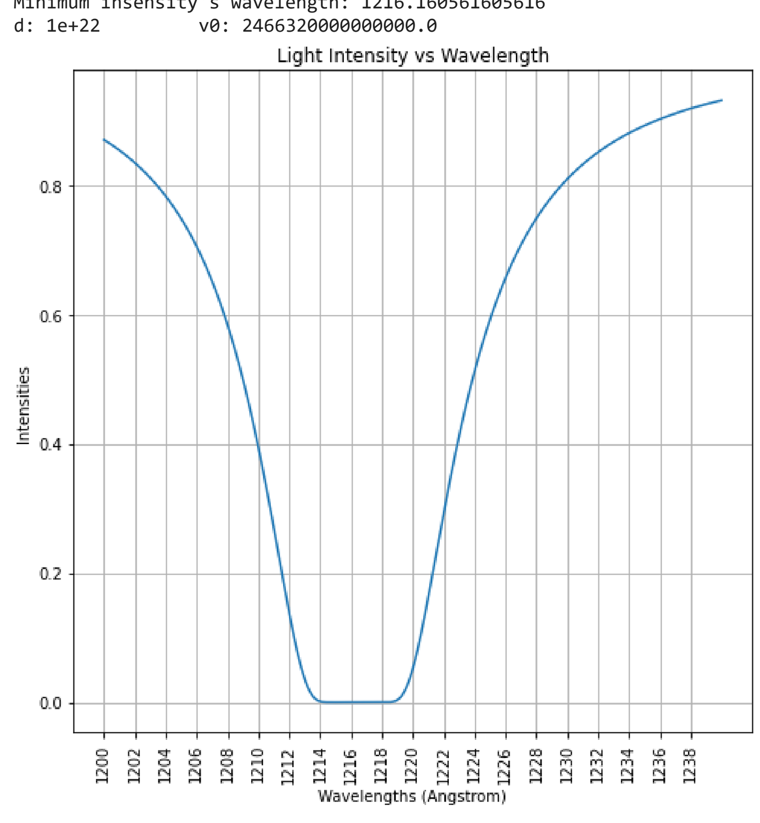
In [10]:
```python
plot_spectrum(d_list[1], v0_new)
```

```
Minimum intensity: 0.0
Minimum insensity's wavelength: 1216.380163801638
d: 1e+19         v0: 2466320000000000.0
```



In [11]:
```python
plot_spectrum(d_list[2], v0_new)
```

```
Minimum intensity: 0.0
Minimum insensity's wavelength: 1216.160561605616
d: 1e+22         v0: 2466320000000000.0
```



Task 2.3 Commenting

- Actually all graphics has 0 intensity. There is some very very very little values in some plottings but we can assume that they are 0.
- All graphs has same shape.
- All graphs minimum intensity in specific wavelength and that that wavelength is 1216 Angstrom.
- When v0 = 2.46632e15 graphics tend to be get 0 intensity faster than v0 = v0 = 2.46607e15 value.
- When d increased more light gets absorbed.
- Lastly, understanding and proofing that Lyman alpha lines was interesting for me. I was scared at the beginning but now I can even comment about it.