Imports

In [58]:
```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from decimal import Decimal
sns.set_theme()
```

Variables

In [59]:
```
#variables values taken from the pdf
n_h = 0.1
x = 0.1
nu_0 = 2.46607e+15
eta = 6.265e+8
f = 0.4164
g_0 = 2
z = 2
m_e = 9.11e-28
c = 3e+10
e = 4.8e-10
d_list = [10e+14, 10e+18, 10e+21]
pi = 3.14159
```

Point 1.

The intensity I of light of a given wavelength λ is given by this equation:

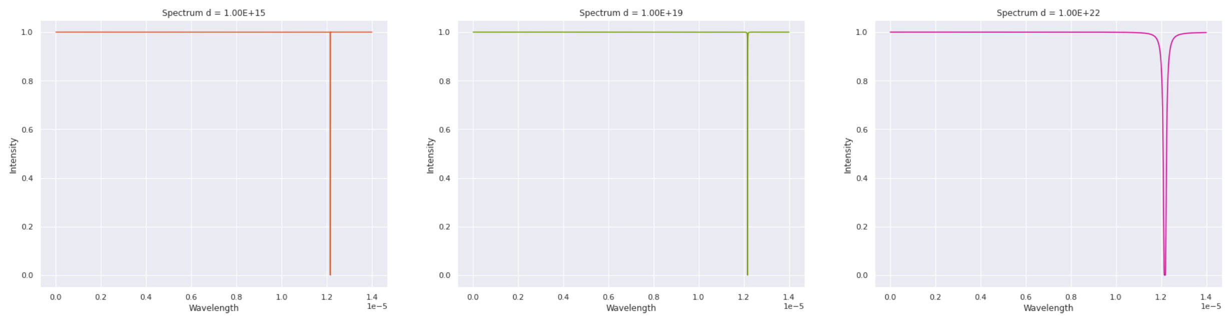
$$I(\lambda) = e^{-\alpha(\nu)d}$$

where the frequency ν is related to λ by $\nu = \frac{c}{\lambda}$. The thickness of the slab is d. The absorption coefficient \alpha(\nu) is given by the following equation:

$$\alpha(\nu) = \frac{e^2 f n_H}{4\pi m_e c} \frac{(1-x)g_0}{z} \frac{\Gamma}{(\nu-\nu_0)^2 + (\Gamma/4\pi)^2}$$

In this formula is not clear if Γ is divided by 4π or by 4 and then multiplied for π. In my implementation, I consider the first option.

In [57]:
```
fig, axs = plt.subplots(nrows=1, ncols=3, figsize = (30,7))
y_limit = [(-0.05, 1.05), (-0.05,1.05), (-0.05,1.05)]
for indx, d in enumerate(d_list):
  lamb = np.linspace(1e-8, 1400 * 1e-8, num = 1000000) #linspace between
800 and 1400
  nu = c/lamb
  alpha = (e**2 * f * n_h)/(4*pi*m_e*c) * ((1-x)*g_0)/z * eta/((nu-nu_0)
**2 + (eta/(4*pi))**2)
  I = np.exp(-alpha * d)
  axs[indx].set_title(f"Spectrum d = {Decimal(d):.2E}")
  axs[indx].plot(lamb, I, c=np.random.rand(3,))
  axs[indx].set_xlabel("Wavelength")
  axs[indx].set_ylabel("Intensity")
  axs[indx].set_ylim(y_limit[indx])
  indx+=1
```



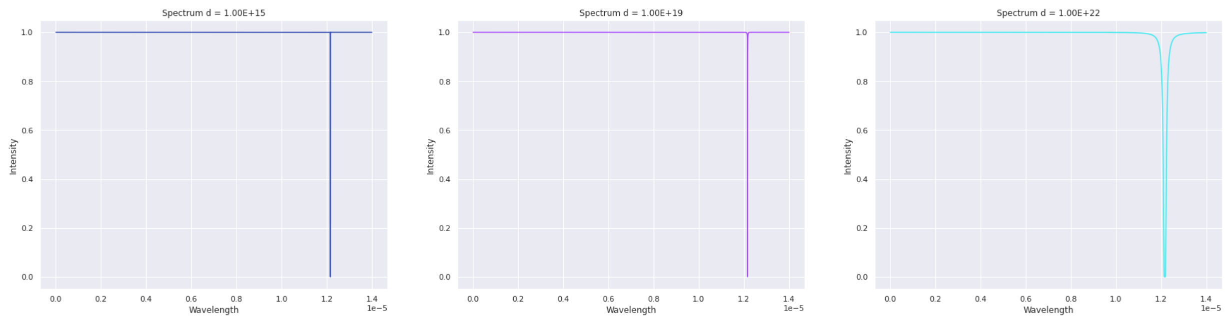
The difference in the thickness parameter d affects the amount of radiation absorbed. This variation results in a greater density of atoms (and consequently of electrons) which leads to greater absorption. This phenomenon is particularly evident in the last two graphs, where the absorption peaks are greater.

Point 2.

If we set $\nu_0 = 2.46632 * 10^{15}$ and we generate again the spectra from question 1:

In [61]:
```
nu_0 = 2.46632e+15
```

In [62]:
```
fig, axs = plt.subplots(nrows=1, ncols=3, figsize = (30,7))
y_limit = [(-0.05, 1.05), (-0.05,1.05), (-0.05,1.05)]
for indx, d in enumerate(d_list):
  lamb = np.linspace(1 * 1e-8, 1400 * 1e-8, num = 1000000) #linspace bet
ween 800 and 1400
  nu = c/lamb
  alpha = (e**2 * f * n_h)/(4*pi*m_e*c) * ((1-x)*g_0)/z * eta/((nu-nu_0)
**2 + (eta/(4*pi))**2)
  I = np.exp(-alpha * d)
  axs[indx].set_title(f"Spectrum d = {Decimal(d):.2E}")
  axs[indx].plot(lamb, I, c=np.random.rand(3,))
  axs[indx].set_xlabel("Wavelength")
  axs[indx].set_ylabel("Intensity")
  axs[indx].set_ylim(y_limit[indx])
  indx+=1
```



The three graphs are very similar to those seen previously. Changing the ν_0 center frequency doesn't affect the final result much. This may be because the change in magnitude of ν_0 is too small compared to the other parameter.