Proton/Carbon equilibration times

It's useful to know the equilibration time between warm protons and cool CIII (ie C2+). We need to calculate the particular Coulomb logarithm for the process, Λ, and do the calculation for a range of densities. At our densities (5×10^{15}, and T=10 eV), equilibration is very fast.

In[1]:=
```
Mp = 1.67 × 10^-24
```
Out[1]=
$$1.67\times10^{-24}$$

In[2]:=
```
MC = 12 * Mp
```
Out[2]=
$$2.004\times10^{-23}$$

In[3]:=
```
Zp = 1
```
Out[3]=
$$1$$

In[4]:=
```
ZC = 2
```
Out[4]=
$$2$$

In[8]:=
```
Λ[np_, nC_, Tp_, TC_] := 23 - Log[13 Zp ZC / (TC + 12 Tp) Sqrt[(np Zp^2 / Tp + nC ZC^2 / TC)]]
```

In[9]:=
```
Λ[10^15, 10^14, 20, 1]
```
Out[9]=
$$23-\text{Log}\left[\frac{390\,000\,000\sqrt{2}}{241}\right]$$

In[10]:=
```
N[%]
```
Out[10]=
$$8.35657$$

In[11]:=
```
Λ[10^16, 10^14, 20, 20]
```
Out[11]=
$$23-\text{Log}\left[200\,000\sqrt{130}\right]$$

In[12]:=
```
N[%]
```
Out[12]=
$$8.36016$$

In[13]:=
```
ΛpC = 8.4
```
Out[13]=
$$8.4$$

It looks like Λ doesn't vary much. Let's pick Λ=8.4. The formula has either np or nC depending on what's colliding with what. Let's see what happens if we look at a wide range of densities.

In[14]:=
```
νpC[np_, nC_, Tp_, TC_] := 1.8 × 10^-19 Sqrt[Mp MC] Zp^2 ZC^2 np ΛpC / (Mp TC + MC Tp)^(3/2)
```

In[20]:=
```
LogLogPlot[1 / vpC[np, nC, 10, 1], {np, 10^13, 10^16}, PlotRange → Full]
```

Out[20]=