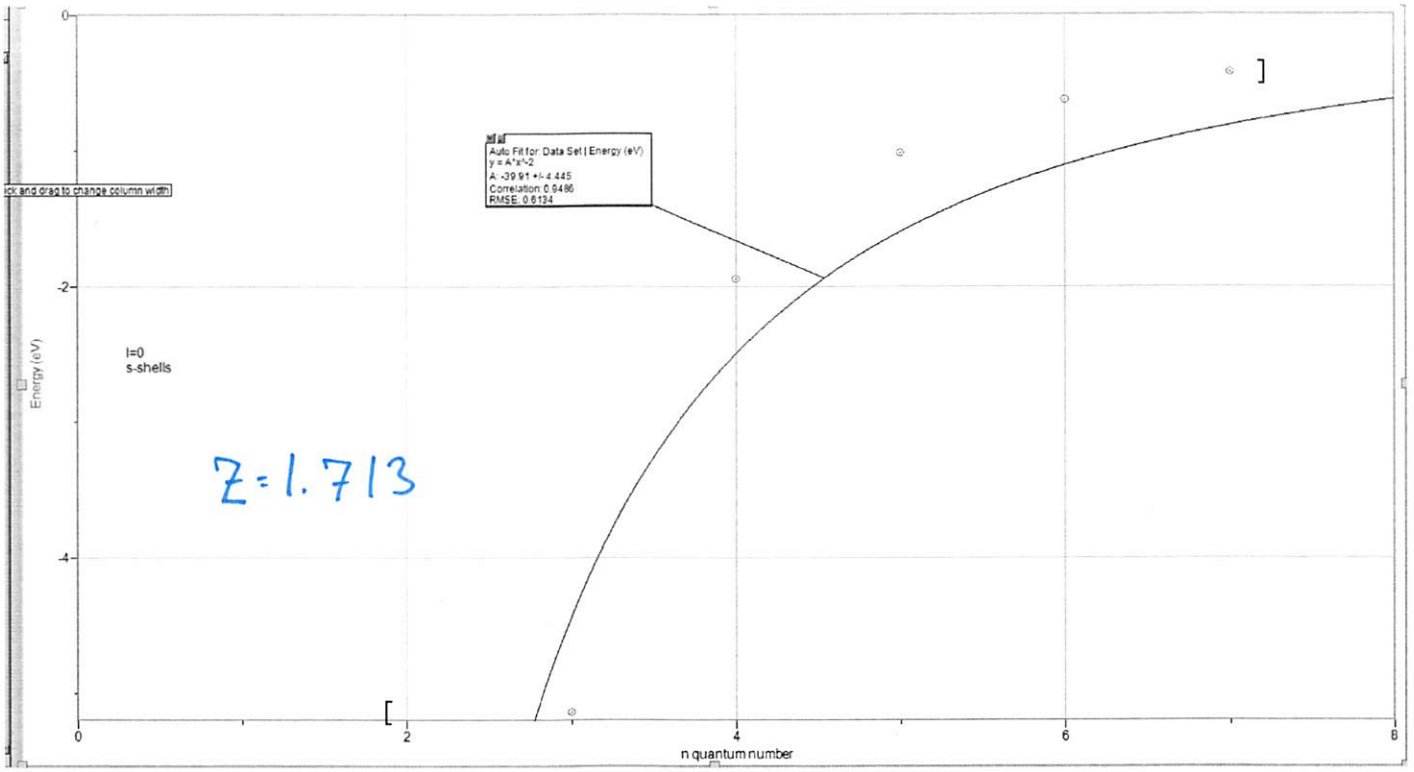
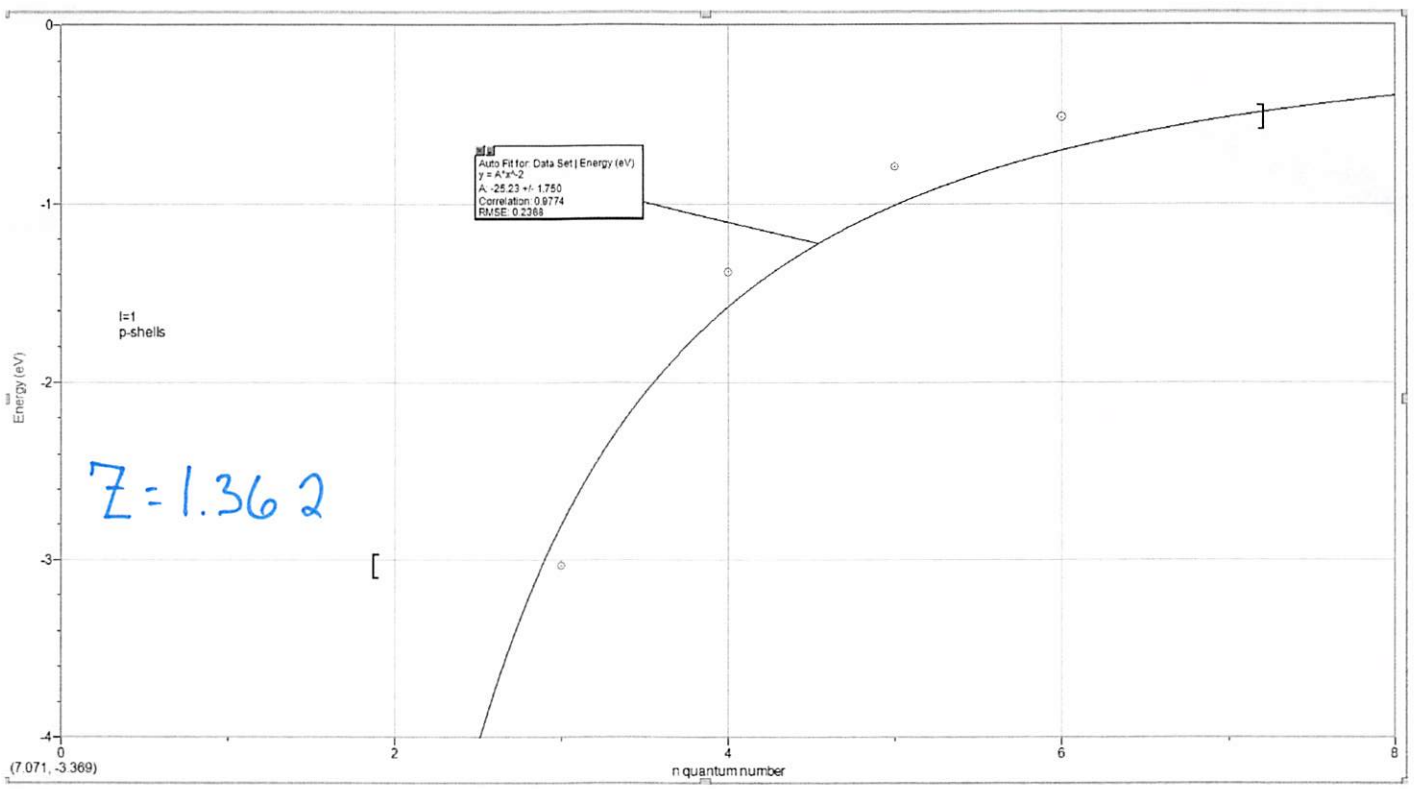
Spectra

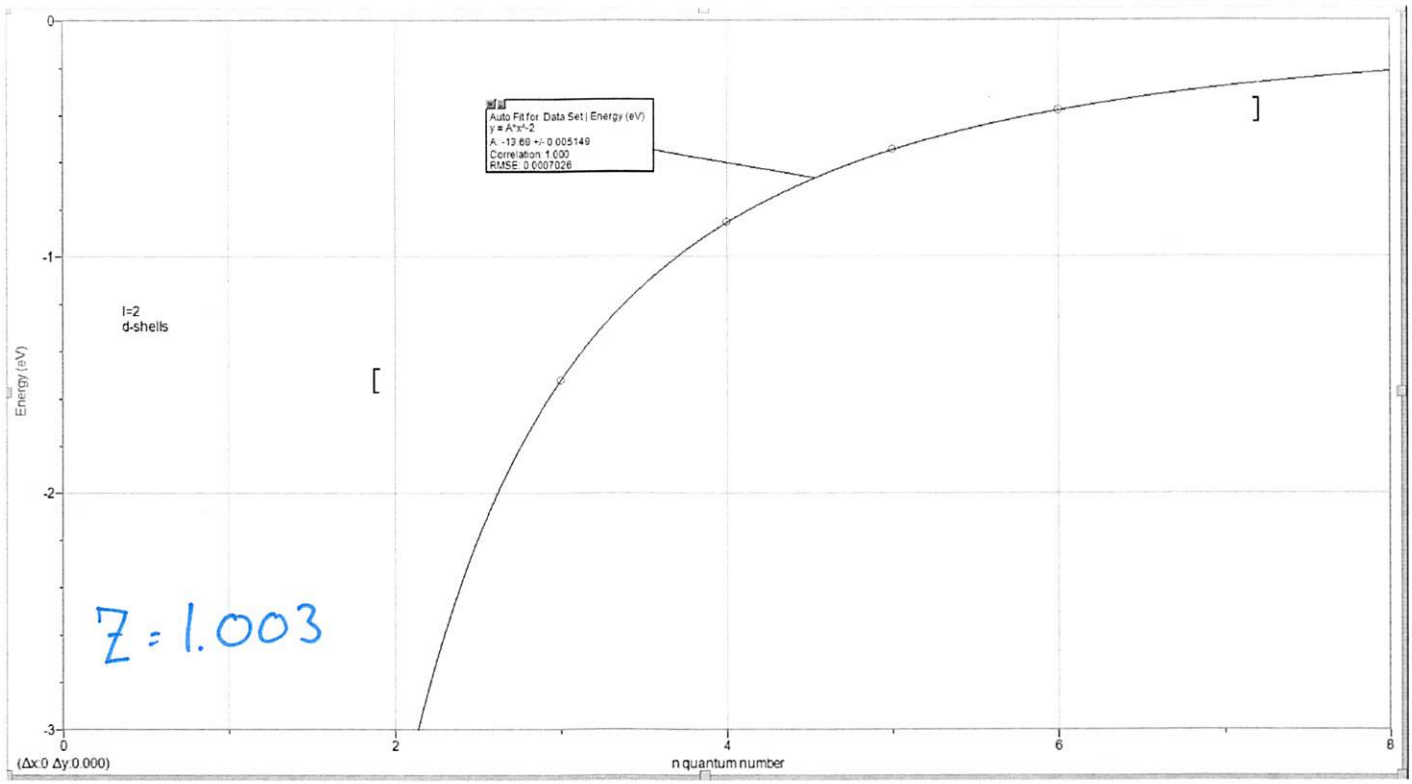
Question 1: The sodium atom has 11 electrons. 10 of them fill up the $n = 1$ and $n = 2$ shells, so the spectrum is primarily determined by the last electron. In this way the sodium spectrum is similar to the hydrogen spectrum. The biggest difference is a l-dependence to the energy levels. When either n or l is large this 11th electron will be far enough out that the 10 inner electrons screen out the charge of all but one of the protons and the energy will be very close to that of hydrogen. But for small n and l this 11th electron will be closer to the nucleus than some of the first 10 electrons; the screening is less so this 11th electron sees a nucleus with a charge greater than $+1e$. This causes the energy to be lower (more tightly bound or more negative) than the corresponding energy level in hydrogen.

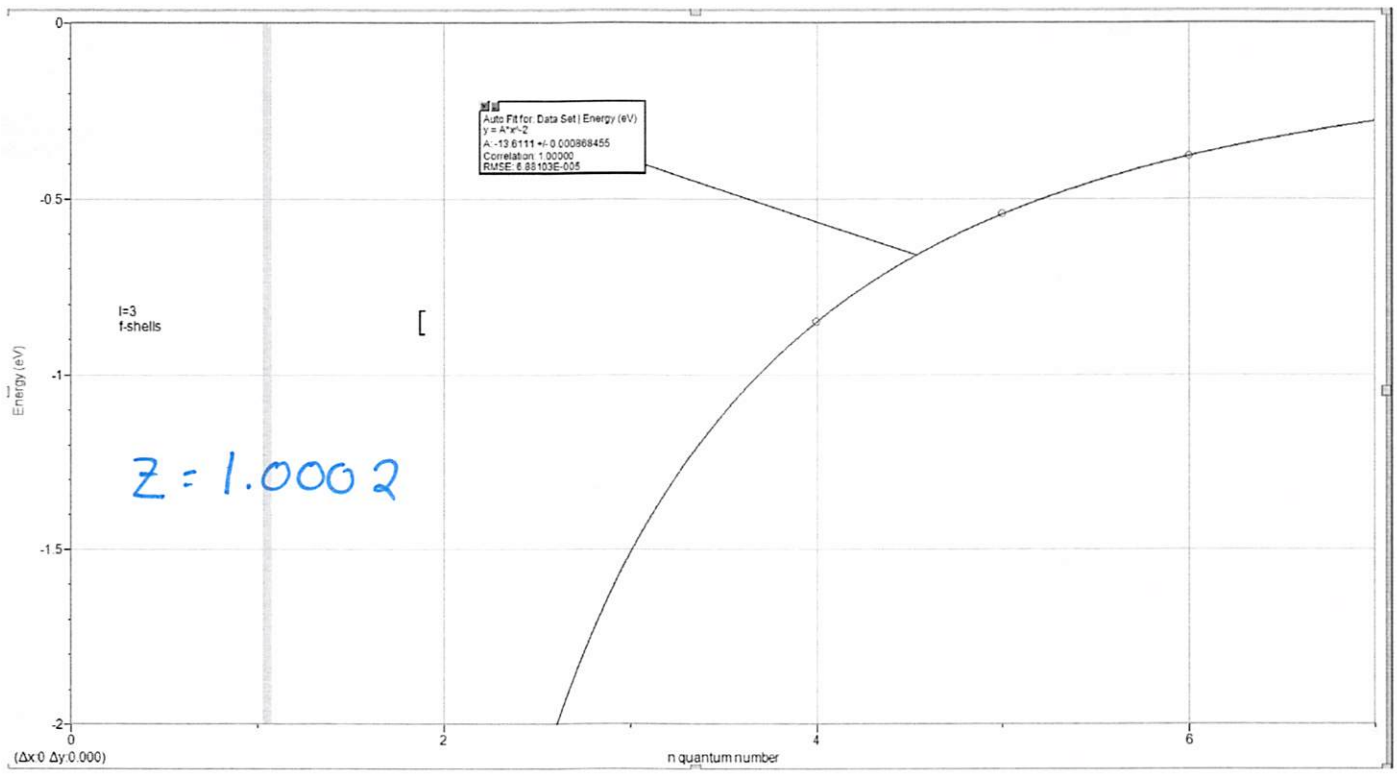
(a) The energy of 16 levels of sodium is given along with the ionization energy in units of inverse centimeters (wave number). (These were taken from `https://physics.nist.gov/PhysRefData/ASD/levels_form.html`) Convert each of these energies, to five significant figures, to units of eV with ionization set to 0.

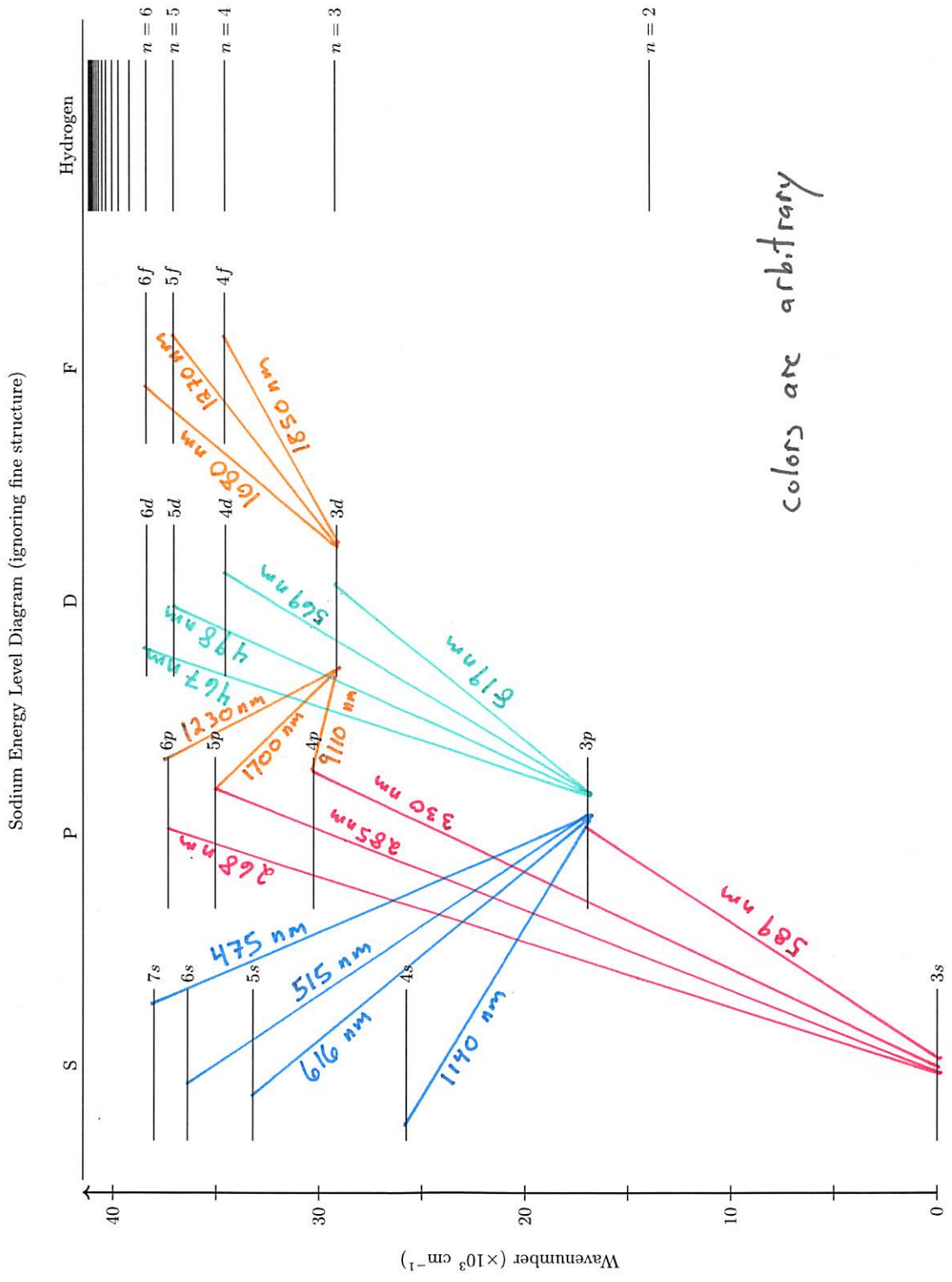
Configuration	Level (cm^{-1})	
3s	0	-5.1389 eV
3p	16,968	-3.0352 eV
4s	25,740	-1.9476 eV
3d	29,173	-1.5220 eV
4p	30,271	-1.3859 eV
5s	33,201	-1.0226 eV
4d	34,549	-0.85546 eV
4f	34,587	-0.85075 eV
5p	35,042	-0.79434 eV
6s	36,373	-0.62932 eV
5d	37,037	-0.54700 eV
5f	37,058	-0.54440 eV
6p	37,297	-0.51477 eV
7s	38,012	-0.42612 eV
6d	38,387	-0.37963 eV
6f	38,400	-0.37802 eV
Ionization	41,449	


Auto Fit for: Data Set | Energy (eV)
y = A*x^-2
A: -39.91 +/- 4.445
Correlation: 0.9486
RMSE: 0.6134
l=0
s-shells
Z=1.713
Energy (eV)
n quantum number


Auto Fit for: Data Set | Energy (eV)
y = A*x^-2
A: -25.23 +/- 1.750
Correlation: 0.9774
RMSE: 0.2368
l=1
p-shells
Z=1.362
Energy (eV)
n quantum number
(7.071, -3.369)


Auto Fit for: Data Set | Energy (eV)
y = A*x^-2
A: -13.60 +/- 0.005149
Correlation: 1.000
RMSE: 0.0007026
l=2
d-shells
Energy (eV)
n quantum number
(Δx:0 Δy:0.000)
Z = 1.003


Auto Fit for: Data Set | Energy (eV)
y = A*x^-2
A: -13.6111 +/- 0.00868455
Correlation: 1.00000
RMSE: 6.88103E-005
l=3
f-shells
Energy (eV)
n quantum number
(Δx:0 Δy:0.000)
Z = 1.0002


Sodium Energy Level Diagram (ignoring fine structure)
Hydrogen
n = 6
n = 5
n = 4
n = 3
n = 2
S
P
D
F
7s
6s
5s
4s
3s
6p
5p
4p
3p
6d
5d
4d
3d
6f
5f
4f
475 nm
515 nm
616 nm
1140 nm
589 nm
330 nm
285nm
268 nm
1230nm
1700 nm
9110 nm
819 nm
569 nm
498 nm
467 nm
1850 nm
1680 nm
1370 nm
colors are arb.trary
Wavenumber (×10³ cm⁻¹)
40
30
20
10
0