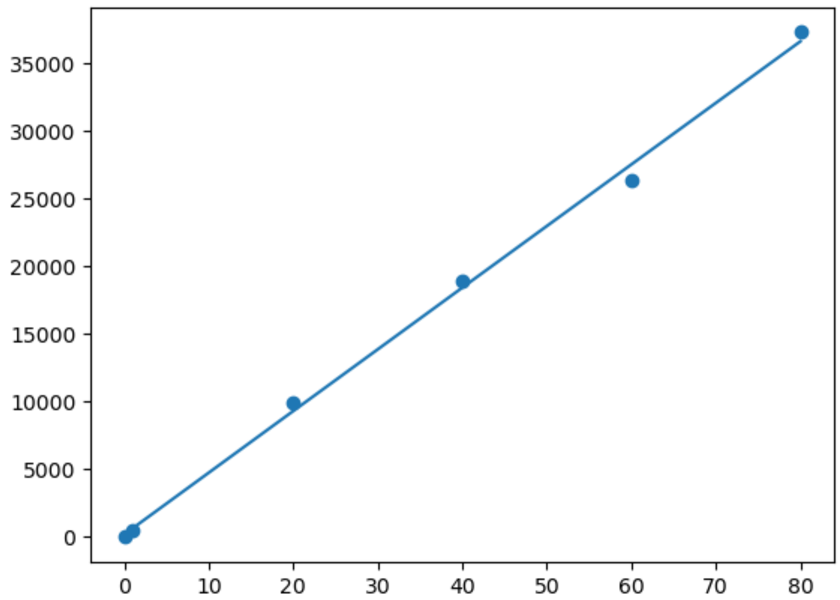
9.1

In [19]:
```
## %matplotlib inline

import numpy as np
import matplotlib.pyplot as plt

exptime = np.array([0., 1., 20., 40., 60., 80.])
DN = np.array([0., 500., 9878., 18955., 26390., 37267.])

plt.scatter(exptime, DN)
coeffs = np.polyfit(exptime, DN, 2)
coeffs[0] *= -1
print("c, b, a: ")
print(coeffs)
plt.plot(exptime, np.polyval(coeffs, exptime))
```

```
c, b, a:
[-1.20903434e-02  4.55822200e+02  2.04106946e+02]
```

Out[19]:
```
[<matplotlib.lines.Line2D at 0x7fadc3078c70>]
```



9.2

We're given a magnitude difference between two stars, but all of the thinking we have in this chapter involves fluxes. So the first thing we need to do is convert the magnitude difference Δm into a relationship in terms of (incorrect) fluxes, F_1' and F_2' -- "incorrect" because they are impacted by the uncorrected non-linear response.

$$\Delta m' = -2.5\log_{10}\left(\frac{F_1'}{F_2'}\right) \Rightarrow \frac{F_2'}{F_1'} = 10^{\Delta m/2.5} = 10^{1.25/2.5} = 3.16,$$

meaning star 2 is *measured* to be 3.16 times brighter than star 1, but because of the non-linearity of our detector, the apparent flux for star 2 is incorrectly estimated.

We're told that star 2 produced a DN value of 30000, meaning star 1 produced a DN value of 10000.

If $F_{1/2}$ is the *corrected* relative flux for star 1/2, then the corresponding output, i.e., data number $\mathrm{DN}_{1/2}$ is given by Equation 9.23:

$$\mathrm{DN}_{1/2} = a + b\left(F_{1/2}t\right) + c\left(F_{1/2}t\right)^2,$$

where t is the exposure time (and we're assuming exposure times for both stars are the same, as indicated).

We can use the quadratic equation to calculate $F_{1/2}t$:

$$F_{1/2}t = \frac{-b \pm \sqrt{b^2 - 4\left(a - \mathrm{DN}_{1/2}\right)c}}{2\,(2c)}.$$

For star 2, we have

$$F_2 t = \frac{-456 \pm \sqrt{(456)^2 - 4\,(204 - 30000)\,(0.012)}}{2\,(0.012)} = 65.$$

For star 1,

$$F_1 t = \frac{-456 \pm \sqrt{(456)^2 - 4\,(204 - 10000)\,(0.012)}}{2\,(0.012)} = 21.$$

Therefore

$$\frac{F_2}{F_1} = 3.1.$$

This result indicates that the actual flux of star 2 is only 3.1 times as large as the flux for star 1. This result is a little strange since the measured (incorrect) fluxes indicate star 2 is 3.16 times brighter than star 1. Something goofy in the data that Chromey have given us. Oh, well.

In any case, we can now estimate the correct relative magnitudes:

$$\Delta m = -2.5\log_{10}\left(\frac{F_1}{F_2}\right) = -2.5\log_{10}(1/3.1) \approx \boxed{1.23}.$$