Atomic units  \( h = m = e = 1 \) (a.u)  
(The units in the electron’s world.)

Length= \( a_0 \)= Bohr radius= \( 0.528 \times 10^{-8} \) cm  
Velocity= \( v_0 \)=electron velocity in 1st Bohr orbit= \( \alpha c = 2.18 \times 10^8 \) cm/s  
Energy= twice of ionization potential of H=\( 27.21 \) eV (called Hartree by chemists)  
Time= \( a_0/v_0 \)= 2.42\( \times 10^{-17} \) sec= 24.2 as  
units of frequency= \( v_0/a_0 \)= 4.13\( \times 10^{16} \) sec\(^{-1}\)  
Electric field = \( e/a_0^2 \)= 5.14\( \times 10^9 \) V/cm

Other units:  
One atomic unit of magnetic field is defined for a Bohr magneton in a B field which has the energy of 13.6 eV. Or \( \mu_B B = 13.6eV \) where \( \mu_B = eh / 2mc = 5.788 \times 10^{-5} \) eV / Tesla  
Thus 1 a.u. of magnetic field = 2.35\( \times 10^5 \) Tesla  
Laser intensity= \( \frac{1}{2} c E^2 \)= 3.51\( \times 10^{16} \) W/cm\(^2\) for peak E field at 1 a.u.

Energy conversion factors  
1 eV = 8065.54 cm\(^{-1}\)  
1 a.u = 27.21396 eV = 219 474.63 05 cm\(^{-1}\)=2 Ry  
1 Ry = 13.6057 eV  
1 degree kelvin = 0.0862 meV (energy units for cold atoms)  
= 0.695 cm\(^{-1}\)  
1 Kcal/mol= 0.0434 eV = 43.4 meV  
(energy units used by chemists)  
1 GHz \( \rightarrow \) 6.6\( \times 10^{-7} \) eV  
(energy units by laser physicists)  
(be careful here-- GHz is the frequency f, to get the energy you need the conversion \( \omega = 2\pi f \) to get it right. Thus 2\( \pi \) x 4.13\( \times 10^{16} \) Hz \( \rightarrow \) 27.21 eV)

Frequently used constants  
Speed of light in vacuum \( c = 2.997 924 580 \times 10^8 \) m/s (exact-by definition)  
Planck’s constant , \( h=6.6260755 \times 10^{-34} \) J-s= 4.136 \( \times 10^{-15} \) eV-s  
electron charge \( q = 1.60217733 \times 10^{-19} \) coulomb  
Avogadro number= 6.022\( \times 10^{23} \)/mole  
Boltzmann’s constant \( k = 1.380658x \times 10^{-23} \) J/K=8.617 \( \times 10^{-5} \) eV/K
Short-hand notations.

$10^9 = \text{giga}, \ 10^{12} = \text{tera}; \ 10^{15} = \text{peta}; \ 10^{18} = \text{exa}; \ 10^{21} = \text{zetta}; \ 10^{24} = \text{yocto}$

$10^{-9} = \text{nano} \ 10^{-12} = \text{pico}; \ 10^{-15} = \text{femto}; \ 10^{-18} = \text{atto}; \ 10^{-21} = \text{zepto}; \ 10^{-24} = \text{yotta}$

Notable wavelengths, frequencies and energies

- Photon wavelength to ionize H: 911 Å
- Lyman-$\alpha$ of H: 1216 Å $\rightarrow$ 10.2 eV or 1 nm $\rightarrow$ 1.24 keV

**Photon** momentum (a.u.) $k = 2.7 \times 10^{-4}$ E (eV)

de Broglie wavelength for **electron**, 100 eV is 1.22 ångstrom

Lasers

For $\lambda = 1$ Å, photon energy= 455.71 au for 800 nm $\rightarrow \omega = 0.057\text{au}$

Laser peak intensity (linear polarized) = $3.5 \times 10^{16}$ W/cm$^2$

$U_p = E^2/4 \omega^2 = 9.33 I(10^{14} \text{W/cm}^2) \lambda^2$ (in $\mu$m)

(6 eV for 800 nm at $10^{14} \text{W/cm}^2$)

Keldysh parameter $\gamma = \sqrt{I/(2U_p)}$

Time-frequency width relation for a chirped pulse: $\Delta \omega = \frac{4 \ln 2}{\tau_s} \sqrt{1 + \xi^2}$

Gaussian pulse

$I(\omega) = e^{-\frac{(\omega-\omega_0)^2}{(4\ln 2)}} \quad E(t) = e^{-2\ln 2t^2/\tau^2}$

($\tau$ is FWHM in time domain)

Width in eV for a Gaussian pulse for $\tau = 1$ fs is 1.83 eV.
1.5. Oscillator strength and transition rates

\[ A = 2\left(\frac{\omega^2}{c^3}\right)f\left(4.13 \times 10^{16}\right) \text{ 1/sec} \]

where \( \omega \) is in a.u., \( c=137.03604 \) and \( f \) is the oscillator strength for emission.