Generally useful constants (MKS):

```
amu = 1.6605 (10^-27) kg
NA = 6.02221 (10^23) / mole
k = 1.38066 (10^-23) J / K
me = 9.1094 (10^-31) kg
h = 6.62608 (10^-34) J s
q = 1.6022 (10^-19) C
c = 2.9979 (10^8) m / s
```

$$1.6605 \times 10^{-27}\ \text{kg}$$

$$\frac{6.02221 \times 10^{23}}{\text{mole}}$$

$$\frac{1.38066 \times 10^{-23}\ \text{J}}{\text{K}}$$

$$9.1094 \times 10^{-31}\ \text{kg}$$

$$6.62608 \times 10^{-34}\ \text{J s}$$

$$1.6022 \times 10^{-19}\ \text{C}$$

$$\frac{2.9979 \times 10^{8}\ \text{m}}{\text{s}}$$

Problem 1.10 (Engel)

What speed does a H_2 molecule have if it has the same momentum as a photon of wavelength 280 nm?

Solution

Strategy. The problem says to equate the momenta of the molecule and the photon. First, calculate this momentum for the photon

$$p = \frac{h}{\lambda}$$

Next, convert this momentum to a velocity for the molecule

$$v = \frac{p}{m}$$

Execution. Calculate momenta for λ = 280 nm (but first convert nm to m).

```
λ = (280. nm) (m / (10^9 nm))
```

2.8×10^{-7} m

```
p = h / λ
```

$$\frac{2.36646 \times 10^{-27}\ \text{J s}}{\text{m}}$$

Calculate molecular mass of H_2

```
mass = 2 * 1.0079 amu
```

3.34724×10^{-27} kg

Calculate velocity

```
v = p / mass
```

$$\frac{0.706988\ \text{J s}}{\text{kg m}}$$

My units look terribly complicated. Simplify by recognizing that J = kg m^2 s^{-2}

```
v * kg * m^2 / (J * s^2)
```

$$\frac{0.706988\ \text{m}}{\text{s}}$$

Comment

Can light slow down matter? It would seem so - all you have to do is direct a photon at an approaching molecule. But don't expect too much from *one* photon. H_2 is a *lightweight* molecule and 280 nm is a high-energy (near UV) photon. To slow down heavier molecules, one would need to use multiple photons (or maybe photons of even higher energy and momentum).