



Energy

- What kinds of energy are there?
- **Kinetic energy (KE)**
 - mass m moving at velocity v $\frac{1}{2}mv^2$
 - mass with moment of inertia I and angular velocity ω $\frac{1}{2}I\omega^2$
- **Potential energy (location in field)**
 - spring $\frac{1}{2}kx^2$
 - gravitational mgz
 - electric Vq
- Units
 - Nm = J, ft lbf, BTU
 - 1 ft lbf $\cong 1.285 \times 10^{-3}$ BTU
 - 1 kJ $\cong 0.948$ BTU



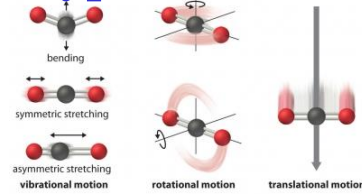
Thermal Energy

- What about the energy that a mass sitting still, in no fields, has...i.e., just because it is “hot”
 - this energy comes from the microscopic structure of the molecules that make up the mass
- Molecules have
 - KE (due to their motions)
 - PE (they have their own electric and other fields)
- Thus they have energy due to their internal structure = **internal energy (U)**

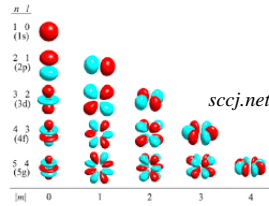


Internal Energy Types

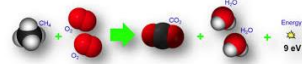
- Translational KE (of center-of-mass)
- Rotational KE (of nuclei about CM)
- Vibrational KE+PE (of nuclei relative to CM)
- Electronic (KE+PE of electrons relative to nuclei)
- Chemical (PE between nuclei)
- Nuclear (within nucleus)
- Intermolecular PE in dense fluid and solid



from DublinSchools.net



sccj.net



Energy Transfer

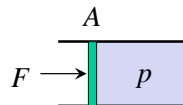
- So total energy that a piece of mass can have is
 - (macroscopic) KE + (macroscopic) PE + U
- But, how can a body/mass gain or lose energy?
 1. Put it into or take it from the organized motion of the mass \equiv **Work, W**

– e.g., push a piston, turn a shaft

$$\delta W = F dx, \quad \delta W = T d\omega$$

$$\delta W = (pA)dx = pdV \quad >0 \text{ work into mass}$$

Work rate (per time) = **Power**

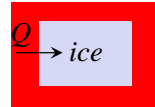




Energy Transfer

2. Transfer between disorganized/random motions of the mass(molecules) \equiv **Heat Transfer, Q**

- e.g., conduction from hot to cold body, like melting ice (as it melts, ice water molecules start moving faster, more randomly)



Heat transfer per time = **Heat transfer rate**

- when system has no heat transfer across its boundaries \equiv **Adiabatic**
 - e.g. by adding insulation around the mass (ice chest, thermos, ...)