

Quantum Mechanics_*Specific energy*

Specific energy

SI unit	J/kg
In SI base units	m^2/s^2
Derivations from other quantities	$e = E/m$

Energy density has tables of specific energies of devices and materials.

Specific energy is energy per unit mass. (It is also sometimes called "energy density," though "energy density" more precisely means energy per unit volume.) It is used to quantify, for example, stored heat or other thermodynamic properties of substances such as specific internal energy, specific enthalpy, specific Gibbs free energy, and specific Helmholtz free energy. It may also be used for the kinetic energy or potential energy of a body. Specific energy is an intensive property, whereas energy and mass are extensive properties.

The SI unit for specific energy is the joule per kilogram (J/kg). Other units still in use in some contexts are the kilocalorie per gram (Cal/g or kcal/g), mostly in food-related topics, watt hours per kilogram in the field of batteries, and the Imperial unit BTU per pound (BTU/lb), in some engineering and applied technical fields.[1] The gray and sievert are specialized measures for specific energy absorbed by body tissues in the form of radiation. The following table shows the factors for converting to J/kg:

Unit	SI equivalent
kcal/g[2]	4.184 MJ/kg
Wh/kg	3.6 kJ/kg
kWh/kg	3.6 MJ/kg
Btu/lb[3]	2.326 kJ/kg
Btu/lb[4]	ca. 2.32444 kJ/kg

The concept of specific energy is related to but distinct from the chemical notion of *molar* energy, that is energy per mole of a substance. Although one mole of a substance has a definite molar mass, the mole is technically a non-dimensional unit, a

pure number (the number of molecules of the substance being measured, divided by Avogadro's constant). Therefore, for molar quantities like molar enthalpy one uses units of energy per mole, such as J/mol, kJ/mol, or the older (but still widely used) kcal/mol.[5]

For a table giving the specific energy of many different fuels as well as batteries, see the article Energy density.

Energy density of food

Energy density is the amount of energy per mass or volume of food. The energy density of a food can be determined from the label by dividing the energy per serving (usually in kilojoules or food calories) by the serving size (usually in grams, milliliters or fluid ounces). Energy density is thus expressed in cal/g, kcal/g, J/g, kJ/g, cal/mL, kcal/mL, J/mL, or kJ/mL. The "calorie" commonly used in nutritional contexts is the kilogram-calorie (abbreviated "Cal" and sometimes called the "dietary calorie", "food calorie" or "Calorie" with a capital "C"). This is equivalent to a thousand gram-calories (abbreviated "cal") or one kilocalorie (kcal). Because food energy is commonly measured in calories, the energy density of food is commonly called "caloric density".[6]

Energy density measures the energy released when the food is metabolized by a healthy organism when it ingests the food (see food energy for calculation) and the food is metabolized with oxygen, into waste products such as carbon dioxide and water. Besides alcohol the only sources of food energy are carbohydrates, fats and proteins, which make up ninety percent of the dry weight of food.[7] Therefore, water content is the most important factor in energy density. Carbohydrates and proteins provide four calories per gram (17 kJ/g), whereas fat provides nine calories per gram (38 kJ/g),[7] 2 ¼ times as much energy. Fats contain more carbon-carbon and carbon-hydrogen bonds than carbohydrates or proteins and are therefore richer in energy.[8] Foods that derive most of their energy from fat have a much higher energy density than those that derive most of their energy from carbohydrates or proteins, even if the water content is the same. Nutrients with a lower absorption, such as fiber or sugar alcohols, lower the energy density of foods as well. A moderate energy density would be 1.6 to 3 calories per gram (7–13 kJ/g); salmon, lean meat, and bread would fall in this category. High-energy foods would have more

than three calories per gram and include crackers, cheese, dark chocolate, and peanuts.[9]

Fuel

Energy density is sometimes useful for comparing fuels. For example, liquid hydrogen fuel has a higher **specific energy** (energy per unit mass) than gasoline does, but a much lower volumetric energy density.

Astrodynamics

Specific mechanical energy, rather than simply energy, is often used in astrodynamics, because gravity changes the kinetic and potential specific energies of a vehicle in ways that are independent of the mass of the vehicle, consistent with the conservation of energy in a Newtonian gravitational system.

The specific energy of an object such as a meteoroid falling on the earth from outside the earth's gravitational well is at least one half the square of the escape velocity of 11.2 km/s. This comes to 63 MJ/kg or 15 kcal/g.

Miscellaneous

- kinetic energy per unit mass: $\frac{1}{2}v^2$, where v is the speed (giving J/kg when v is in m/s). See also kinetic energy per unit mass of projectiles.
- potential energy with respect to gravity, close to earth, per unit mass: gh , where g is the acceleration due to gravity (standardized as $\sim 9.8 \text{ m/s}^2$) and h is the height above the reference level (giving J/kg when g is in m/s^2 and h is in m).
- heat: energies per unit mass are specific heat capacity times temperature difference, and specific melting heat, and specific heat of vaporization

References

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