

1.3: Extensive and Intensive Quantities

There is a useful and important distinction in thermodynamics between extensive (or “capacitive”) and *intensive* quantities.

Extensive quantities are those that depend upon the amount of material. Examples would include the volume, or the heat capacity of a body. The *heat capacity* of a *body* is the amount of heat required to raise its temperature by one degree, and might be expressed in $\text{J } ^\circ\text{C}^{-1}$.

Intensive quantities do not depend on the amount of material. Temperature and pressure are examples. Another would be the *specific heat capacity* of a *substance*, which is the amount of heat required to raise unit mass of it through one degree, and it might be expressed in $\text{J kg}^{-1} ^\circ\text{C}^{-1}$. This is what is commonly (though loosely) called “the specific heat”, but we shall use the correct term: *specific heat capacity*.

Incidentally, we would all find it much easier to understand each other if we all used the word “specific” in contexts such as these to mean “per unit mass”.

“Molar” quantities are also intensive quantities. Thus the “molar heat capacity” of a substance is the amount of heat required to raise the temperature of one *mole* of the substance through one degree. I shall have to define “mole” in the next section.

Some authors adopt the convention that extensive quantities are written with capital letters, and the corresponding intensive quantities are written in small letters. Thus C would be the heat capacity of a body in $\text{J } ^\circ\text{C}^{-1}$ and c would be the specific heat capacity of a substance in $\text{J kg}^{-1} ^\circ\text{C}^{-1}$. This is undeniably a useful distinction and one that many will find helpful. I have a few difficulties with it. Among these are the following: Some authors (not many) use the opposite convention – small letters for extensive quantities, capitals for intensive. Some authors make exceptions, using P and T for the intensive quantities pressure and temperature. Also, how are we to distinguish between extensive, specific and molar quantities? Three different fonts? This may indeed be a solution – but there is still a problem. For example, we shall become familiar with the equation $dU = T dS - P dV$. Here U , S and V are internal energy, entropy and volume. Yet the equation (and many others that we could write) is equally valid whether we mean extensive, specific or molar internal energy, entropy and volume. How do we deal with that? Write the equation three times in different fonts?

Because of these difficulties, I am choosing *not* to use the capital letter, small letter, convention, and I am hoping that the context will make it clear in any particular situation. This is, I admit, rather a leap of faith, but let’s see how it works out.

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