# Key for The Cooling of Metals

Imagine you have samples of aluminum, copper, gold, and silver. Each sample is in the form of a cube, with sides 1 cm in length, and is suspended by a thread from a wooden dowel. The metals are placed in a beaker of boiling water where they remain until the water returns to a boil. All four metals are now at a temperature of 100 °C. If you remove the samples and place them on a block of ice, which metal will melt the most ice as the metal cools to 0°C? You many assume that no heat is lost in other ways. Use the web site Chemicool (www.chemicool.com) to find any information regarding the metals that you need to solve this problem.

Although the four metals experience the same change in temperature as they cool from 100°C to 0°C, they do not release the same amount of energy. To determine the amount of energy released by each metal we use the equation

$$q = mS\Delta T$$

where $q$ is the amount of energy released in Joules, $m$ is the metal's mass in grams, $S$ is the metal's specific heat in J/g • °C and $\Delta T$ is the change in temperature. To find the mass for each cube of metal we need each metal's density so we can convert volume to mass. The densities and the specific heats for the four metals, as reported at the web site Chemicool, are shown in the following table:

| metal | density (g/cm$^3$) | S (J/g • °C) |
|---|---|---|
| aluminum | 2.702 | 0.90 |
| copper | 8.96 | 0.38 |
| gold | 19.32 | 0.128 |
| silver | 10.5 | 0.235 |

Because the cubes have a volume of 1 cm$^3$, each metal's density is the same as its mass. The amount of heat released by each metal is

$$q_{\mathrm{Al}} = (2.702g) \times (0.90J/g \bullet^o C) \times (0^oC - 100^oC) = -243J \approx -240\mathrm{J}$$

$$q_{\mathrm{Cu}} = (8.96g) \times (0.38J/g \bullet^o C) \times (0^oC - 100^oC) = -340J \approx -340\mathrm{J}$$

$$q_{\mathrm{Au}} = (19.32g) \times (0.128J/g \bullet^o C) \times (0^oC - 100^oC) = -247J \approx -250\mathrm{J}$$

$$q_{\mathrm{Ag}} = (10.5g) \times (0.235J/g \bullet^o C) \times (0^oC - 100^oC) = -247J \approx -250\mathrm{J}$$

The cube of metal that melts the most ice is the one fashioned from copper because it releases the most energy as it cools from 100°C to 0°C.