

Specific heat of water (4,186 J/kg·K) and the specific heat capacity table of 45 substances

Water's specific heat	4,186 J/(kg·K) = 4.184 J/(g·°C) = 1 cal/(g·°C) = 1 kcal/(kg·°C) = 1 Btu/(lb·°F) = 75.3 J/(mol·K); rounded to 4,200 in many courses
-----------------------	--

The energy needed to raise 1 kg of a substance by 1 degree. A kelvin and a degree Celsius are the same size of step. Water's is high because heat goes into stretching hydrogen bonds, not only into molecular speed: that is why coasts have mild climates, bodies hold their temperature, and water is the coolant in engines.

The table: J/(kg·K) at room temperature (divide by 1,000 for J/(g·°C))

Substance	c	Substance	c	Substance	c
Water (liquid)	4,186	Oxygen	918	Glass	840
Ice (-10 C)	2,090	Carbon dioxide	839	Concrete	880
Steam (100 C)	2,010	Aluminium	900	Brick	840
Seawater	3,990	Iron	450	Marble	880
Ammonia (liquid)	4,700	Steel	490	Granite	790
Ethanol	2,440	Copper	385	Sand	830
Glycerine	2,430	Brass	380	Dry soil	800
Olive oil	1,970	Zinc	388	Asphalt	920
Milk	3,900	Nickel	444	Wood	1,700
Human body	3,500	Titanium	523	Rubber	2,000
Mercury	140	Tin	228	Paraffin wax	2,900
Hydrogen gas	14,300	Silver	235	Diamond	509
Helium	5,190	Tungsten	134	Graphite	710
Air (const. pressure)	1,005	Gold	129	Polystyrene	1,300
Nitrogen	1,040	Lead	128	Paper	1,340

Pattern: metals low (a kilogram of copper warms ten times faster than water for the same heat), water and the light gases high, rock, glass and soil around 800 to 900. Per atom most solids are alike (about 25 J/(mol·K), the Dulong-Petit rule); metals look low per kilogram because their atoms are heavy.

Latent heat: energy with no temperature change (Q = mL)

Ice to water at 0 °C (fusion)	334 kJ/kg
Water to steam at 100 °C (vaporisation)	2,260 kJ/kg
1 kg of ice at 0 °C to steam at 100 °C	334 + 419 + 2,260 = 3,013 kJ; boiling is three quarters of it

From

sciencewithshobha.com/blog/specific-heat-of-water-4186-j-per-kg-k-what-it-means-why-it-is-so-high-the-specific-heat-table-of-common-substances-and-q-mc-del-ta-t-worked-examples/ · 1-on-1 online physics and chemistry, free 30-minute first class.

Q = mcΔT: the formula, worked examples and practice

$Q = m \times c \times \Delta T$. Q heat in joules; m mass in kg (grams if c is per gram); c in J/(kg·K); ΔT the CHANGE in temperature (final minus initial), the same in K and °C. Rearranged: $c = Q \div (m\Delta T)$, $\Delta T = Q \div (mc)$, $m = Q \div (c\Delta T)$.

Worked examples

The question	The working	The answer
Heat 2 kg of water from 20 to 100 °C	$2 \times 4,186 \times 80$	669,760 J (670 kJ)
250 g of water for tea, 20 to 90 °C	$0.25 \times 4,186 \times 70$	73,255 J; a 2 kW kettle takes 37 s
Heat a 0.5 kg aluminium pan by 150 °C	$0.5 \times 900 \times 150$	67,500 J
10,000 J into 1 kg of copper: how much warmer?	$10,000 \div (1 \times 385)$	26 °C
10,000 J into 1 kg of water: how much warmer?	$10,000 \div (1 \times 4,186)$	2.4 °C
A 100 g block gains 2,300 J and warms 50 °C: c?	$2,300 \div (0.1 \times 50)$	460 J/(kg·K): iron or steel
200 g of coffee cools from 90 to 60 °C: heat out	$0.2 \times 4,186 \times 30$	25,116 J

Practice

- [] 1. Energy to warm 1.5 kg of water from 15 to 65 °C?
- [] 2. The same for 1.5 kg of aluminium?
- [] 3. 500 J into 100 g of water: temperature rise?
- [] 4. 500 J into 100 g of gold: temperature rise?
- [] 5. A 2 kg steel block (c = 490) cools from 300 to 20 °C: heat given out?
- [] 6. 0.4 kg warms 25 °C with 12,900 J: c, and what might it be?
- [] 7. A 3 kW kettle, 1.2 kg of water at 18 °C: time to 100 °C?
- [] 8. Energy to melt 0.5 kg of ice at 0 °C?
- [] 9. Energy to boil away 0.5 kg of water at 100 °C?
- [] 10. Why does beach sand get hotter than the sea?

Answers

- 1) 313,950 J 2) 67,500 J 3) 1.2 °C 4) 38.8 °C 5) 274,400 J 6) 1,290 J/(kg·K): polystyrene or paper 7) $411,906 \text{ J} \div 3,000 \text{ W} = 137 \text{ s}$ 8) 167,000 J 9) 1,130,000 J 10) sand's c (830) is a fifth of water's, so the same sunshine warms it about five times as much