Thermochemical Calculations

Formulas, Constants, and Unit Conversions — Chemistry Reference Sheet — California Standards Test

Formulas

Ideal Gas Law: $PV = nRT$

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Pressure Formula: $P = \frac{F}{A}$

Mass-Energy Formula: $E = mc^2$

Calorimetric Formulas –

No Phase Change: $Q = m(\Delta T)C_p$

Latent Heat of Fusion: $Q = m\Delta H_{fus}$

Latent Heat of Vaporization: $Q = m\Delta H_{vap}$

Constants

Volume of Ideal Gas at STP: $22.4\ \frac{L}{mol}$

Speed of Light in a Vacuum: $c = 3.00 \times 10^8\ \frac{m}{s}$

Specific Heat of Water: $C_p(H_2O) = 1.00\ \frac{cal}{(g\ ^\circ C)} = 4.18\ \frac{J}{(g\ ^\circ C)}$

Latent Heat of Fusion of Water: $\Delta H_{fus}(H_2O) = 80\ \frac{cal}{g} = 334\ \frac{J}{g}$

Latent Heat of Vaporization of Water: $\Delta H_{vap}(H_2O) = 540\ \frac{cal}{g} = 2260\ \frac{J}{g}$

Unit Conversions

Calorie-Joule Conversion: $1\ cal = 4.184\ J$

CA Standards

Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.
Students know how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.

Units for Measuring Heat

The **Joule** is the SI system unit for measuring heat:

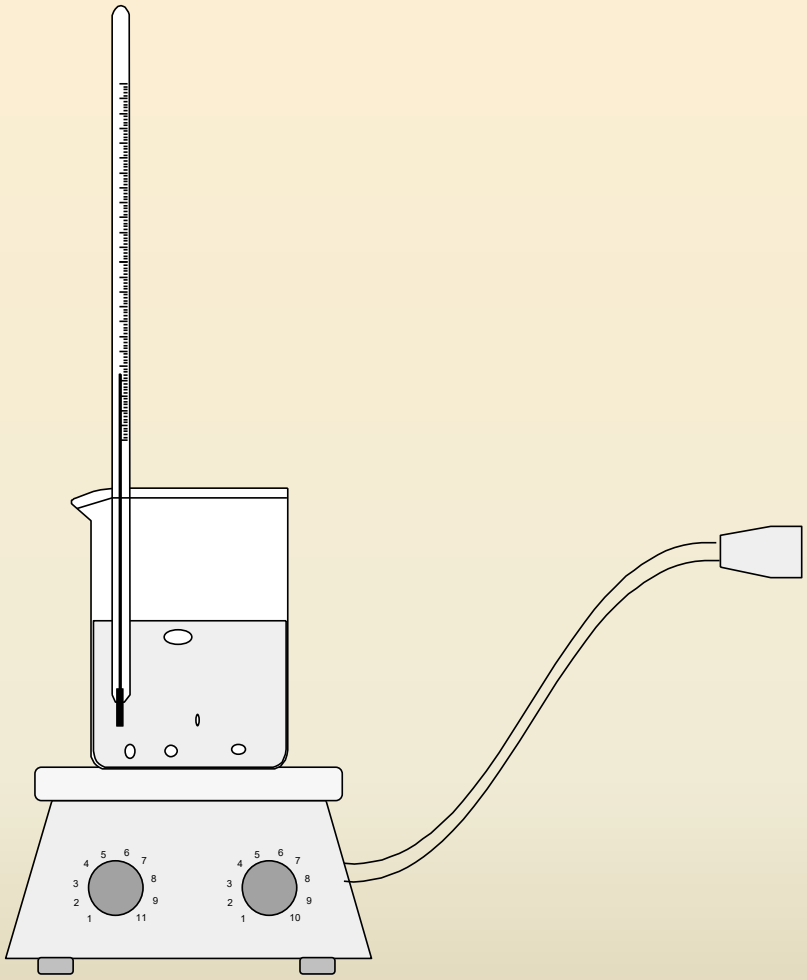
$$1\,Joule = 1\,newton \cdot meter = \frac{1\,kg \cdot m^2}{s^2}$$

The **calorie** is the heat required to raise the temperature of 1 gram of water by 1 Celsius degree

$$1\,calorie = 4.18\,Joules$$

Specific Heat

The amount of heat required to raise the temperature of one gram of substance by one degree Celsius.



Calculations Involving Specific Heat

$$Q = m \cdot \Delta T \cdot c_p \quad \text{OR} \quad c_p = \frac{Q}{m \cdot \Delta T}$$

c_p = Specific Heat

Q = Heat lost or gained

ΔT = Temperature change

m = Mass

Specific Heat

The amount of heat required to raise the temperature of one gram of substance by one degree Celsius.

Substance	Specific Heat (J/g·K)
Water (liquid)	4.18
Ethanol (liquid)	2.44
Water (solid)	2.06
Water (vapor)	1.87
Aluminum (solid)	0.897
Carbon (graphite,solid)	0.709
Iron (solid)	0.449
Copper (solid)	0.385
Mercury (liquid)	0.140
Lead (solid)	0.129
Gold (solid)	0.129

Latent Heat of Phase Change

Molar Heat of Fusion

The energy that must be absorbed in order to convert one mole of solid to liquid at its melting point.

Molar Heat of Solidification

The energy that must be removed in order to convert one mole of liquid to solid at its freezing point.

Latent Heat of Phase Change #2

Molar Heat of Vaporization

The energy that must be absorbed in order to convert one mole of liquid to gas at its boiling point.

Molar Heat of Condensation

The energy that must be removed in order to convert one mole of gas to liquid at its condensation point.

Latent Heat – Sample Problem

Problem: The molar heat of fusion of water is 6.009 kJ/mol. How much energy is needed to convert 60 grams of ice at 0°C to liquid water at 0°C?

$$\frac{60\,g\,H_2O}{}\left|\frac{1\,mol\,H_2O}{18.02\,g\,H_2O}\right|\frac{6.009\,kJ}{1\,mol\,H_2O}=20\,kiloJoules$$

Mass of ice

Molar Mass of water

Heat of fusion

Heat of Solution

The **Heat of Solution** is the amount of heat energy absorbed (endothermic) or released (exothermic) when a specific amount of solute dissolves in a solvent.

Substance	Heat of Solution (kJ/mol)
NaOH	-44.51
NH_4NO_3	+25.69
KNO_3	+34.89
HCl	-74.84