

Calorimetry

- Outline: Zumdahl 9.4 Comments on Calorimetry (and application to Lab)
- What is heat capacity
- How do we measure heat, need standards
- Use a calorimeter to determine the heat from a reaction (physical or chemical).
- Problems (for practice) Z9.32,Z9.38

Heat Capacity: C

- The ability of a substance to take up heat as the temperature goes up.
- Apply heat, e.g. heat water over a burner; doing this in the air is a process at constant pressure.

$$q = q_P = C_p \Delta T$$

Temperature is intensive, heat is extensive, so heat capacity must be extensive.

The extensive and intensive versions of heat capacity are:

$$C_P = n c_P$$

For water,

$$c_P = 1 \text{ cal} / \text{ gm} / ^\circ\text{C} = 4.18 \text{ J} / \text{ gm} / ^\circ\text{C} = 75.2 \text{ J} / \text{ mol} / ^\circ\text{C}$$

Standardize the Heat

- Use electricity to generate an exact amount of heat.
- When a (coulomb of) electron falls through 1 V of potential it loses (as heat, q) 1J of energy.
- One mole of electrons gives you 96,500 Coulombs of charge; this tells you the charge on an electron.

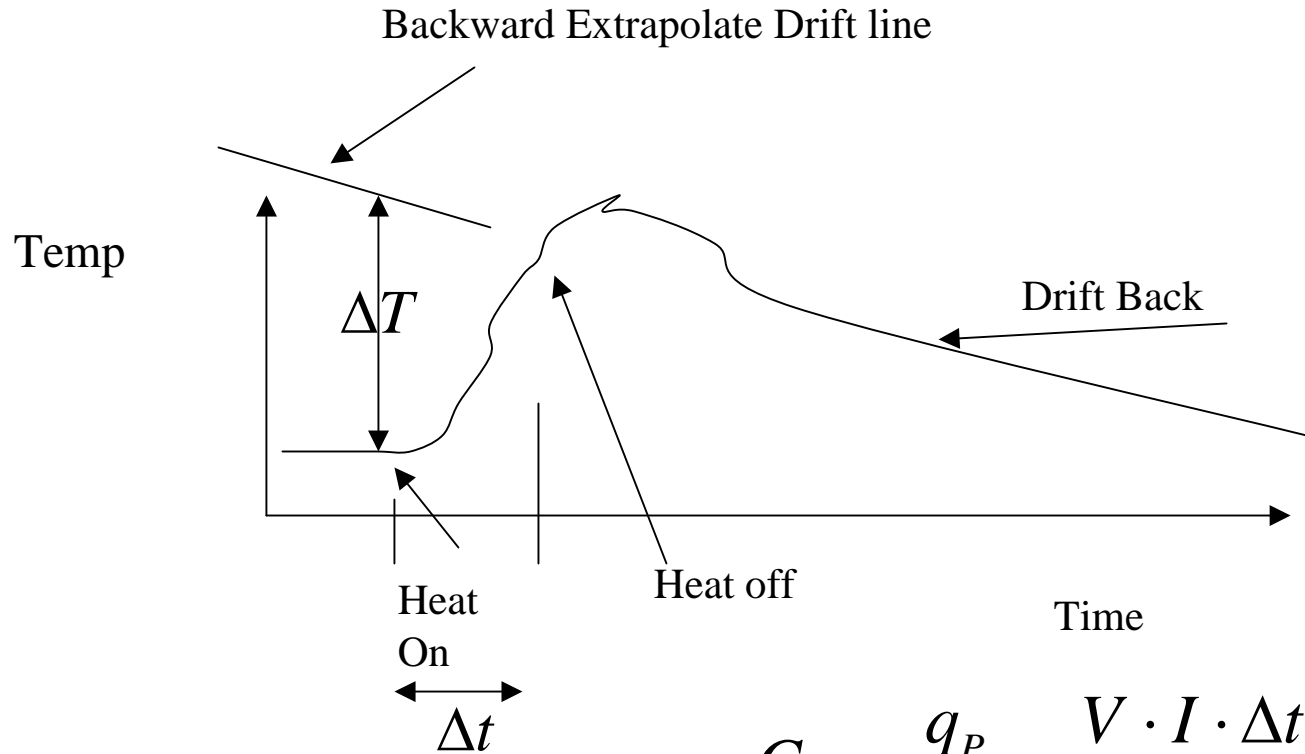
$$1Volt = 1Joule / Coulomb$$

$$1Amp = 1Coul / second$$

$$q = \Delta E(J) = V \cdot \Delta Q = V \cdot I \cdot \Delta t$$

Put a heating element in the water of the calorimeter (dixie cup and 60 mls of water). Be sure to stir. Measure temperature for a while, turn on heater, turn it off, measure temp for a while afterwards. Your heat capacity should be about 250 J/K. Why?

How a Temp vs Time curve might look



$$C_P = \frac{q_P}{\Delta T} = \frac{V \cdot I \cdot \Delta t}{\Delta T}$$

The heat of fusion of ice.

As a sample problem to illustrate the lab:

The calorimeter has a heat capacity of 250J/K, at room Temp, $T_0=20\text{C}$, to which is added 5 gm of ice at 0C (you really should check this). If the temperature of the calorimeter drops to 10C , what is the heat of fusion of ice. Assume that the heat capacity of water is 4.18J/gK , over this temperature range.

Heat that goes into the ice from the calorimeter.

$$q_{ICE} = m \cdot \Delta H_f + (T_f - 0)m \cdot c_{water}$$

ΔH_f = heat of fusion (J/g)

$m=5\text{g}$; mass of ice; $c_{water}=4.18\text{J/g-K}$ water

T_f = final temperature of calorimeter and ice

Temperature change of calorimeter due to ice

$$q = C_P (T_f - T_o) = -q_{ICE}$$

Heat that flows out of calorimeter must flow into the ice, so notice the change in sign here.

Algebra

Finish the problem. The answer is larger than the literature value, so the final temperature is just approximate (12.4C would be closer to the real number). The important point is that you follow the logic of the heat flow.

$$q_{ICE} = m \cdot \left\{ \Delta H_f + (T_f - 0) \cdot c_{water} \right\} = -C_P (T_f - T_o) = 250 \cdot 10J$$

$$\left\{ \Delta H_f + 10 \cdot 4.18 \right\} = 250 \cdot \frac{10}{5} J / g = 500J / g$$

$$\Delta H_f = 458J / g$$

It is rather remarkable to think that 5 grams of ice cooled 60 grams of water by almost 8 degrees. What does this say about what glacial ice is doing for our planet? What happens when it is gone (which will be soon)!!!???