Calorimeters

Notes and Examples

Solving calorimeter questions

Heat released by the reaction = heat absorbed by the calorimeter + the water in the calorimeter

Specific heat capacity is listed in data booklet

Example A

Substance X has a molar mass of 107.6 g/mol. When 2.50 g of substance X burns in an iron calorimeter, the temperature of the calorimeter (1.250 kg) and the water (2.000 kg) increases from 25.8°C to 38.7°C. Calculate the heat of combustion of substance X in kJ/mol.

Heat released by reaction = heat absorbed by calorimeter + water in calorimeter

$q = mc\Delta t(\text{calorimeter}) + mc\Delta t(\text{water})$

$q = (1.250\ \text{kg})(0.444\ \text{kJ/kg°C})(12.9°\text{C}) + (2.000\ \text{kg})(4.18\ \text{kJ/kg°C})(12.9°\text{C})$

$q = 7.1595\ \text{kJ} + 107.844\ \text{kJ}$

$q = 115.0035\ \text{kJ}$

The water and the calorimeter absorb 115 kJ of energy. ∴ when 2.50 g of X burns, it releases 115 kJ

$$n = \frac{\text{mass}}{\text{molar mass}} = \frac{2.50\ \text{g}}{107.6\,\text{g/mol}} = 0.0232\ \text{mol}$$

Set up a ratio to solve for the heat for one mole.

$$\frac{0.0232\ \text{mol}}{1} = \frac{-115\ \text{mol}}{x}$$

$$x = -4949.75064\ \text{kJ/mol}$$

$$\Delta H_{comb} = -4950\ \text{kJ/mol}$$

(note: the heat is now negative because substance X releases heat when it burns)

Example B

50.0 mL of 0.800 mol/L hydrobromic acid was added to 50.0 mL of 0.800 mol/L potassium hydroxide in a styrene cup. Initial temperature of both solutions was 23.18°C. Final temperature was 26.38°C. Calculate the heat of reaction per mole of hydrobromic acid.

$HBr(aq) + KOH(aq) \rightarrow KBr(aq) + H_2O(l)$

Notes:

1. When a styrene (Styrofoam) cup is used, often it is ignored in the calculations. It is assumed that the heat absorbed by the cup is negligible. If the heat absorbed by the cup should be included in the calculations, information about the heat capacity or specific heat capacity will be given in the question.
2. When a dilute solution is used, treat the solution as if it was water. This means that the solution is treated as if it has the same density as water (1.00 g/mL) and the same specific heat capacity as water (4.18 J/g°C)

Heat released by reaction = heat absorbed by calorimeter + water in calorimeter
Heat released by reaction = heat absorbed by water in calorimeter (ignoring the styrene cup)

$q = mc\Delta t$	-	the two solutions are the "water"
$q = (100.0\ g)(4.18\ J/g°C)(3.20°C)$	-	50.0 g HBr + 50.0 g KOH = 100.0 g "water"
$q = 1337.6\ J$		

1.34 kJ is absorbed by the water in the calorimeter,
$\therefore$1.34 kJ is released when 50.0 mL of HBr reacts

$$C = \frac{n}{V}$$

$$n = CV = (0.800\ \text{mol/L})(0.0500\ \text{L}) = 0.0400\ \text{mol HBr}$$

$\therefore$ 1.34 kJ is released when 0.0400 mol HBr reacts
set up a ratio to calculate the heat for one mole

$$\frac{0.0400\ \text{mol}}{1.00\ \text{mol}} = \frac{-1.34\ \text{kJ}}{x}$$

$$x = -33.44\ \text{kJ/mol}$$

$$\Delta H_{rxn} = -33.4\ \text{k J/mol}$$