Stoichiometry and Heat Capacity

1. Calculate the heat evolved (kJ) for the reaction in which 9.00 g of $C_6H_{12}O_6$ is fermented to form ethyl alcohol
(Atomic weights: C = 12.01, H = 1.008, O = 16).

$$C_6H_{12}O_6(s) \longrightarrow 2\ C_2H_5OH(l) + CO_2(g)$$
$$\Delta H^\circ = -67.0\ kJ$$

$$9.00\ g\ C_6H_{12}O_6 \times \frac{1\ mol\ C_6H_{12}O_6}{180\ g\ C_6H_{12}O_6} \times \frac{-67.0\ kJ}{1\ mol\ C_6H_{12}O_6} = \boxed{-3.35\ kJ}$$

2. Calculate the heat energy (kJ) released when 15 g of Fe_3O_4 reacts with excess Al according to the following reaction.
(Atomic weights: Fe = 55.85, Al = 26.98, O = 16.00).

$$3\ Fe_3O_4(s) + 8\ Al(s) \longrightarrow 4\ Al_2O_3(s) + 9\ Fe(s)$$
$$\Delta H^\circ = -3347.6\ kJ$$

$$15.0\ g\ Fe_3O_4 \times \frac{1\ mol\ Fe_3O_4}{231.6\ g\ Fe_3O_4} \times \frac{-3347.6\ kJ}{3\ mol\ Fe_3O_4} = \boxed{-72.3\ kJ}$$

3. What quantity of heat is liberated by a reaction that produces 50.0 g of SO_2 in the following reaction?
(Atomic weights: Ni = 58.69, O = 16.00, S = 32.06).

$$2\ NiS(s) + 3\ O_2(g) \longrightarrow 2\ NiO + 2\ SO_2(g)$$
$$\Delta H^\circ = -936.2\ kJ$$

$$50.0\ g\ SO_2 \times \frac{1\ mol\ SO_2}{64\ g\ SO_2} \times \frac{-936.2\ kJ}{2\ mol\ SO_2} = \boxed{-366\ kJ}$$

4. A 25.0 g piece of copper at 25.0°C is put into an insulated vessel containing 100 g of water at 40.0°C. What will be the final temperature (°C) of the water? The specific heat of copper and water are 0.385 J/g°C and 4.18 J/g°C respectively.

$m_1 s_1 \Delta T_1 = m_2 s_2 \Delta T_2$

$q_{Cu(+)}$ $q_{H_2O(-)}$

$$m_{Cu} s_{Cu} \Delta T_{Cu} = -m_{H_2O} s_{H_2O} \Delta T_{H_2O}$$
$$(25.0g)(0.385\ J/g°C)(T_f - 25.0°C) = -(100g)(4.18\ J/g°C)(T_f - 40.0°C)$$
$$9.625 T_f - 240.625 = -418 T_f + 16720$$
$$427.625 T_f = 16960.625$$
$$\boxed{T_f = 39.7°C}$$

5. How much heat energy (kJ) must be supplied to heat 400.0 g of isopropyl alcohol from 20.0°C to 60.0°C in a stainless steel vessel weighing 550.0 g. The specific heat of isopropyl alcohol and stainless steel are 2.58 J/g°C and 0.51 J/g°C respectively.

$$q_{total} = q_{alcohol} + q_{vessel} = (400.0g)(2.58\ J/g°C)(60.0-20.0°C) + (550.0g)(0.51\ J/g°C)(60-20$$
$$q = 52500\ J = \boxed{52.5\ kJ}$$

6. A sheet of 10.0 g of copper at 22.0°C is placed on a 20.0 g sheet of aluminum at 75.0°C. What is the final temperature of the two metals assuming that no heat is lost to the surroundings. The specific heats of copper and aluminum are 0.385 J/g°C and 0.900 J/g°C respectively.

$$m_{Cu} s_{Cu} \Delta T_{Cu} = -m_{Al} s_{Al} \Delta T_{Al}$$
$$(10.0g)(0.385\ J/g°C)(T_f - 22.0°C) = -(20.0g)(0.900\ J/g°C)(T_f - 75.0°C)$$
$$3.85 T_f - 84.7 = -18 T_f + 1350$$
$$21.85 T_f = 1434.7$$
$$\boxed{T_f = 65.7°C}$$