Ch. 6 Discussion ?’s

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• First Law of Thermodynamics
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• Heat of Solution and Dilution
  – 6.68, 6.70
6.10 Decomposition reactions are usually endothermic whereas combination reactions are usually exothermic. Give a qualitative explanation for these trends.

**Answer:**

Decomposition: $AB \rightarrow A + B$; breaking bonds

Combination: $A + B \rightarrow AB$; making bonds

Endothermic: requires energy

Exothermic: releases energy
6.19 Calculate the work done when 50.0 g of tin dissolves in excess acid at 1.00 atm and 25°C:

\[ \text{Sn}(s) + 2\text{H}^+(aq) \rightarrow \text{Sn}^{2+}(aq) + \text{H}_2(g) \]

Assume ideal gas behavior.

**Answer:**

\[ W = -P\Delta V \]

\[ P = 1 \text{ atm} \quad \Delta V = \text{calculate from the rxn} \]

\[ \text{g Sn} \rightarrow \text{mol H}_2 \rightarrow \text{L H}_2 = \Delta V \]

\[ PV = nRT \quad V = \frac{nRT}{P} \]
6.26 Determine the amount of heat (in kJ) given off when $1.26 \times 10^4$ g of NO$_2$ are produced according to the equation

$$2\text{NO}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)$$

$\Delta H = -114.6$ kJ/mol

**Answer:**

$$2\text{NO}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) + 114.6 \text{ kJ}$$

$$\text{g NO}_2 \rightarrow \text{mol NO}_2 \rightarrow \text{kJ}$$
Consider the reaction

\[ \text{H}_2 (g) + \text{Cl}_2 (g) \rightarrow 2\text{HCl}(g) \]

\[ \Delta H = -184.6 \text{ kJ/mol} \]

If 3 moles of \( \text{H}_2 \) react with 3 moles of \( \text{Cl}_2 \) to form \( \text{HCl} \), calculate the work done (in joules) against a pressure of 1.0 atm at 25°C. What is \( \Delta E \) for this reaction? Assume the reaction goes to completion.

**Answer:**

\[ E = q + w; \ E = \Delta H - PdV \]

\( 6 \text{ mol gas} \rightarrow 6 \text{ mol of gas} ; \ dV = 0 ; \ E = \Delta H \)
A 0.1375-g sample of solid magnesium is burned in a constant-volume bomb calorimeter that has a heat capacity of 3024 J/°C. The temperature increases by 1.126 °C. Calculate the heat given off by the burning Mg, in kJ/g and in kJ/mol.

**Answer:**

Draw a picture

Heat of calorimeter temp change = heat of rxn

°C → J → kJ

kJ → kJ/g → kJ/mol
6.45 Which of the following standard enthalpy of formation values is not zero at 25°C? \( \text{Na}_\text{(s)}, \text{Ne}_\text{(g)}, \text{CH}_4\text{(g)}, \text{S}_8\text{(s)}, \text{Hg}_\text{(l)}, \text{H}_\text{(g)}. \)

**Answer:**

\[ \Delta H^\circ_f = 0 \]; element in standard state

i.e. \( \text{Na}_\text{(s)}, \text{Ne}_\text{(g)}, \text{S}_8\text{(s)}, \text{Hg}_\text{(l)} \)

\( \text{CH}_4\text{(g)} \) and \( \text{H}_\text{(g)} \) are nonzero
The ΔH°ₙ values of the two allotropes of oxygen, O₂ and O₃, are 0 and 142.2 kJ/mol, respectively, at 25°C. Which is the more stable form at this temperature?

**Answer:**

In thermodynamics, generally lower E = more stable

O₂ = more stable

ΔH°ₙ = 0 ; element in standard state

More stable allotrope = standard state
6.48 Predict the value of $\Delta H^\circ_f$ (greater than, less than, or equal to zero) for these elements at 25°C

(a) $\text{Br}_2$ (g); $\text{Br}_2$ (l),

(b) $\text{I}_2$ (g); $\text{I}_2$ (s)

**Answer:**

$\Delta H^\circ_f = 0$; element in standard/stable state

(a) $\text{Br}_2$ (l) is most stable form of Br; equal to 0

$\text{Br}_2$ (g) less stable than $\text{Br}_2$ (l); $> 0$

(b) $\text{I}_2$ (s) most stable form of I; equal to 0

$\text{I}_2$ (g) less stable than $\text{I}_2$ (s); $> 0$
6.55 Methanol, ethanol, and n-propanol are three common alcohols. When 1.00 g of each of these alcohols is burned in air, heat is liberated as shown by the following data: (a) methanol (CH$_3$OH), -22.6 kJ; (b) ethanol (C$_2$H$_5$OH), -29.7 kJ; (c) n-propanol (C$_3$H$_7$OH), -33.4 kJ. Calculate the heats of combustion of these alcohols in kJ/mol.

**Answer:**

kJ/g $\rightarrow$ kJ/mol
The standard enthalpy change for the following reaction is 436.4 kJ/mol:

\[ \text{H}_2 (g) \rightarrow \text{H} (g) + \text{H} (g) \]

Calculate the standard enthalpy of formation of atomic hydrogen (H).

**Answer:**

\[ \Delta H^\circ_{\text{rxn}} = \Sigma \Delta H^\circ_{f \text{products}} - \Sigma \Delta H^\circ_{f \text{reactants}} \]

\[ \Delta H^\circ_{f \text{H}_2(g)} = 0 \text{ kJ/mol} \]

Solve for \( \Delta H^\circ_{f \text{H}(g)} \)
**6.68** Mg$^{2+}$ is a smaller cation than Na$^+$ and also carries more positive charge. Which of the two species has a larger hydration energy (in kJ/mol)? Explain.

**Answer:**

Mg = more charge in smaller space; $Z_{\text{eff}}$: Mg$^{2+} >$ Na$^+$

large $Z_{\text{eff}}$ = strong ion-dipole with H$_2$O = small $E_{\text{hyd}}$

Na$^+$ has larger hydration energy
6.70 Why is it dangerous to add water to a concentrated acid such as sulfuric acid in a dilution process?

Answer: Very high heat of dilution