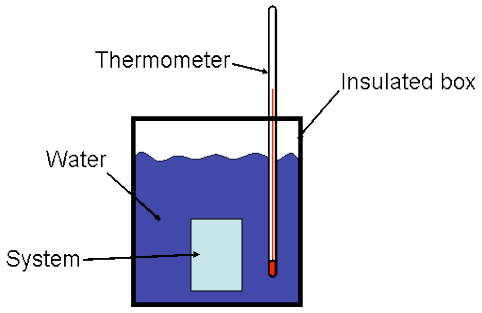
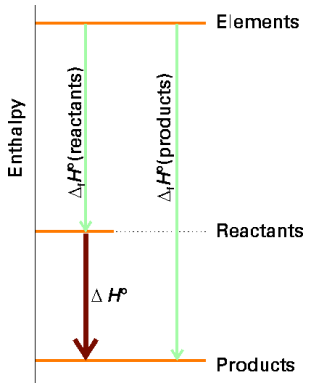
Chapter 5 Summary Notes

Main Concepts	Explanations
• ***0th and 1st Laws of Thermodynamics:***	
0. 2 systems are in thermal equilibrium when they are at the same T	
1. Energy can be neither created nor destroyed, or, energy is conserved	
• ***Internal Energy***	
• Includes translational, rotational, vibrational energy	
• Change ($\Delta E = E_{final} - E_{initial}$) is often measured	
○ $\Delta E > 0$: Energy of system increases (gained from surr.)	**Ex.** Octane and Oxygen gases combust within a closed cylinder in an engine. The cylinder gives off 1150J of heat and a piston is pushed down by 480J during the reaction. What is the change in internal energy of the system? (Ans: $\Delta E = -1630J$)
○ $\Delta E < 0$: Energy of system decreases (lost to surr.)	
○ $\Delta E = q + w$	
▪ q = heat added/liberated from system	
• $q > 0$: heat added to system	
• $q < 0$: heat removed from system	
▪ w = work done on or by the system	
• $w > 0$: work done to system	
• $w < 0$: system does work on surr.	
• ***Calorimetry:*** Measurement of heat flow, experimental technique used to measure the heat transferred in a physical or chemical process	
○ Calorimeter: the apparatus used in this procedure; two types: constant pressure (coffee cup) and constant volume (bomb calorimeter)	**Ex.** How much energy is required to heat 40.0 g of iron (c = 0.45J/gK) from 0.0°C to 100.0°C? (Ans: q = 1800J)
○ Coffee Cup Calorimeter: system in this case is the "contents" of the calorimeter and the surroundings are cup and the immediate surroundings	
○ $q_{rxn} + q_{solution} = 0$	**Ex.** 0.500g of Mg chips are placed in a coffee-cup calorimeter and 100.0mL of 1.00M HCl is added to it. The reaction is: $Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$ The temp. of the solution increases from 22.2C to 44.8C. What's the enthalpy change for the reaction, per mole of Mg? Assume specific heat capacity of solution is 4.20J/gK and density of the HCl solution is 1.00 g/mL. (Ans: $\Delta H = -4.64*10^5$ J/molMg)
▪ q_{rxn}: heat gained/ lost in the chemical reaction	
▪ $q_{solution}$: the heat gained/lost by solution	
	
• ***Heat Capacity, C:*** Amount of heat required to raise T of an object by 1 K	
○ $q = C\Delta T$	
• ***Specific Heat (or Specific Heat Capacity), c:*** heat capacity of 1 g of substance	
○ $q = mc\Delta T$	

Chapter 5 Summary Notes Contd.

Main Concepts	Explanations
• ***Enthalpy, H***: change in heat content of a reaction at **constant P** ○ $H = E + PV \rightarrow \Delta H = \Delta E + P\Delta V \rightarrow \Delta H = (q_p+w) + (-w) \rightarrow \Delta H = q_p$ ▪ q_p = heat content ▪ $\Delta H > 0$: heat gained from surr. + ΔH in endothermic reaction ▪ $\Delta H < 0$: heat released to surr. + ΔH in exothermic reaction	**Ex.** What is the ΔH of combustion of 100g CH_4 if ΔH_{rxn}^o = -890kJ? (Ans: -5550kJ)
• ***Enthalpy of Reaction, ΔH_{rxn}:*** heat of reaction, extensive property, depends on states of reactions and products ○ $\Delta H_{rxn} = -\Delta H_{reverse\ rxn}$	**Ex**. What is ΔH_{rxn}^o of the combustion of propane? $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ Givens: $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ $\Delta H_1 = -103.85kJ$ $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_2 = -393.5kJ$ $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$ $\Delta H_3 = -285.8kJ$ (Ans: ΔH_{rxn}^o = -2219.8kJ)
• ***Hess's Law:*** If a rxn is carried out in a series of steps: $\Delta H_{rxn} = \Sigma(\Delta H_{steps}) = \Delta H_1 + \Delta H_2 + \Delta H_3 + \cdots$	
• ***Enthalpy of Formation, ΔH_f:*** heat needed to form substance from its elements ○ Standard Enthalpy of Formation, ΔH_f^o: forms 1 mole of compound from its elements in their standard state (at 298K) ○ ΔH_f of pure element (C, O_2, H_2, etc) is 0.  $\Delta H_{rxn}^o = \Sigma [n*\Delta H_f^o(products)] - \Sigma[n*\Delta H_f^o(reactants)]$	**Ex**. What is ΔH_{rxn}^o for the combustion of liquid benzene? $C_6H_6(l) + 15/2O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$ Givens: $\Delta H_f^o(C_6H_6(l))$ = +49 kJ/mol $\Delta H_f^o(CO_2(g))$ = -394 kJ/mol $\Delta H_f^o(H_2O(l))$ = -286 kJ/mol (Ans: ΔH_{rxn}^o = -3268 kJ/mol)
• ***Bond Enthalpy***: Amount of energy required to break a particular bond between two elements in gaseous state ○ Indicates the "strength" of a bond $\Delta H_{rxn} \approx \Sigma [\Delta H_{bonds\ broken}] - \Sigma[\Delta H_{bonds\ formed}]$ ○ NOTE: this is the "opposite" of Hess's Law	**Ex**. What is ΔH_{rxn}^o for the following reaction? $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$ Given: ΔH/mol of C-H bond: +413 kJ/mol ΔH/mol of H-Cl bond: +431 kJ/mol ΔH/mol of C-C bond: +348 kJ/mol ΔH/mol of Cl-Cl bond: +242 kJ/mol ΔH/mol of C-Cl bond: +328 kJ/mol ΔH/mol of C=C bond: +614 kJ/mol (Ans: $\Delta H_{rxn}^o \approx$ -104 kJ/mol)

Summary of the page and Important things to remember: