

$w = -P\Delta V$        $\Delta E = q + w$        $\Delta H = \Delta E + P\Delta V$        $q = \text{heat capacity} \times \text{mass} \times \Delta T$   
 heat transferred at constant volume:  $q_v = \Delta E$   
 heat transferred at constant pressure:  $q_p = \Delta H$   
 101 J/L\*atm

1. (1 point) Which of the following is not a type of energy or energy flow?  
**a. Temperature**      b. Work      c.  $P\Delta V$       d. Heat      e. Chemical energy
2. (1 point) Positive work is done **on** the system when:  
 a.  $\Delta V = 0$       **b.  $\Delta V < 0$**       c.  $\Delta E > 0$       d.  $\Delta V > 0$       e. none of these
3. (2 points) What is the first law of thermodynamics?

**Energy can not be created nor destroyed. It can change forms.**

4. (1 point) Which of the following can be interpreted as a measure of randomness?  
 a. enthalpy **b. entropy** c. free energy d. temperature e. none of these
5. (1 point) The enthalpy of fusion of water is positive and corresponds to which physical change  
 a.  $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$       d.  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$   
 b.  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$       e.  $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{g})$   
**c.  $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$**       f. none of these
6. (3 points) Calculate the work that is done (in kJ) on the surroundings when a gas expands from 2.5 L to 15.0 L against a constant external pressure (1.2 atm).

$$\begin{aligned}
 15 - 2.5 &= 12.5 \text{ L} \\
 12.5 \text{ L} \times 1.2 \text{ atm} &= 15 \text{ L} \times \text{atm} \\
 15 \text{ L} \times \text{atm} \times 101 \text{ J}/(\text{L} \times \text{atm}) &= 1.51 \times 10^3 \text{ J} \text{ or } 1.51 \text{ kJ}
 \end{aligned}$$

7. (5 points) Aluminum metal reacts with chlorine with a spectacular display of sparks. How much heat is released from the reaction of 10.00 grams of Al with an excess amount of chlorine gas.



**-1408 kJ per 2 moles of Aluminum**

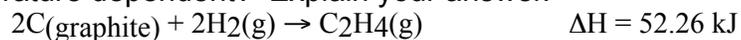
$$10.00 \text{ g Al} \times 1 \text{ mole Al}/26.98 \text{ g} \times -1408 \text{ kJ}/2 \text{ moles Al} = -260.9 \text{ kJ} \text{ or } -2.609 \times 10^2 \text{ kJ}$$

8. (4 points) The specific heat of copper is  $0.385 \text{ (J/g } ^\circ\text{C)}$ . A piece of copper weighs  $20.2 \text{ grams}$  and starts out at  $24^\circ\text{C}$ . It then absorbs  $1.234 \text{ kJ}$  of energy. What is the new temperature?

$$1.234 \times 10^3 \text{ J} = 0.385 \text{ J/g } ^\circ\text{C} \times 20.2 \text{ g} \times (T_f - 24 \text{ } ^\circ\text{C})$$

$$T = 182.6 \text{ } ^\circ\text{C}$$

9. (2 points) Is the following reaction always spontaneous, always non spontaneous or temperature dependent? Explain your answer.



$\Delta S$  is negative. The products are less random (less moles of gas) than the reactants.

$$+\Delta H - T(-\Delta S) = +\Delta G, \text{ non spontaneous}$$

10. (1 point) Which combination always results in a reaction being spontaneous?
- a.  $\Delta H$  is negative and  $\Delta S$  is negative.      **b.  $\Delta H$  is negative and  $\Delta S$  is positive.**  
c.  $\Delta H$  is positive and  $\Delta S$  is negative.      d.  $\Delta H$  is positive and  $\Delta S$  is positive.