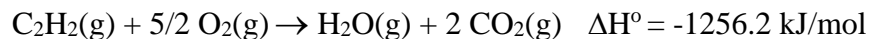


**CHEM 1311**  
**Homework**  
**Thermochemistry**

- (8.40) Calculate the work done in joules by a chemical reaction if the volume increases from 3.2 L to 3.4 L against a constant external pressure of 3.6 atm.
- (8.41) The addition of H<sub>2</sub> to C=C double bonds is an important reaction used in the preparation of margarine from vegetable oils. 50.0 mL of H<sub>2</sub> reacts with 50.0 mL ethylene (C<sub>2</sub>H<sub>4</sub>) at 1.5 atm producing ethane (C<sub>2</sub>H<sub>6</sub>) with a volume of 50.0 mL. Calculate the amount of PV work done and tell the direction of the energy flow.  
$$\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$$
- (8.42) Assume that the nutritional content of an apple (50 Cal) could be used to light a lightbulb (1 Cal = 1000cal). Calculate how many minutes would there be light for each of the following:
  - A 100 watt incandescent bulb (1W = 1 J/s)
  - A 23 watt compact fluorescent bulb, which provides a similar amount of light
- (8.50) When 1.045 g of CaO is added to 50.0 mL of water at 25.0 °C in a calorimeter, the temperature of the water increases to 32.3 °C. Given a specific heat of the solution is 4.18 J/(g · °C) and that the calorimeter itself absorbs a negligible amount of heat, calculate ΔH in kilojoules for the reaction: 
$$\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2 \text{(aq)}$$
- (8.52) When a solution containing 8.00 g of NaOH in 50.0 g of water at 25.0 °C is added to a solution of 8.00 g of HCl in 250.0 g of water at 25.0 °C in a calorimeter, the temperature of the solution increases to 33.5 °C. Given a specific heat for the solution of 4.18 J/(g · °C) and the calorimeter absorbs a negligible amount of heat, calculate ΔH in kilojoules for the reaction. 
$$\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$$
- (8.57) Which of the following has the highest enthalpy content, and which the lowest at a given temperature: H<sub>2</sub>O(s), H<sub>2</sub>O(l), or H<sub>2</sub>O(g)
- (8.58) The enthalpy change for the reaction of 50.0 mL of ethylene with 50.0 mL of H<sub>2</sub> produces 50 mL of ethane at 1.5 atm is ΔH = -0.31 kJ/mol. Find the value of ΔE.  
$$\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6 \quad (\text{Refer to problem \#2})$$

8. (8.59) Assume that a particular reaction evolves 244 kJ of heat and that 35 kJ of PV work is gained by the system. What are the values of  $\Delta E$  and  $\Delta H$  for the system? For the surroundings?

9. (8.62) Used in welding metals, the reaction of acetylene with oxygen has a  $\Delta H^\circ = -1256.2$  kJ/mol.



Determine PV work done in kilojoules and the value of  $\Delta E$  in kilojoules for the reaction of 6.50 g of acetylene at atmospheric pressure providing a volume change of -2.80 L.

10. (8.63) Ethyl chloride ( $\text{C}_2\text{H}_5\text{Cl}$ ), a substance used as a topical anesthetic, is prepared by the reaction of ethylene with hydrogen chloride.

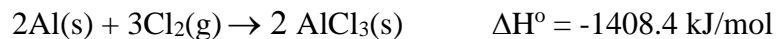


How much PV work is done in kilojoules and what is the value of  $\Delta E$  in kilojoules if 89.5 g of ethylene and 125 g HCl react at atmospheric pressure and the volume change is -71.5 L?

11. (8.64) The familiar “ether” used as an anesthetic agent is diethyl ether,  $\text{C}_4\text{H}_{10}\text{O}$ . Its heat of vaporization is + 26.5 kJ/mol at its boiling point. Determine the amount of energy required to convert 100mL of diethyl ether at its boiling point from liquid to vapor if its density is 0.7138 g/mL.

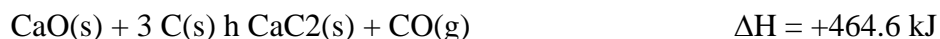
12. (8.65) Calculate the energy in kilojoules is required to convert 100 mL of water at its boiling point from liquid to vapor. [ $\Delta H_{\text{vap}}(\text{H}_2\text{O}) = +40.7$  kJ/mol]

13. (8.66) Aluminum metal reacts with chlorine with a spectacular display of sparks:

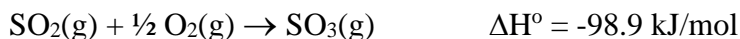


Calculate the amount of heat in kilojoules released by reacting 5.00 g Al.

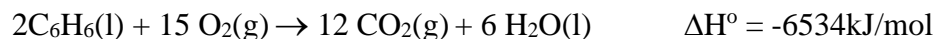
14. (8.69) How much heat in kilojoules is evolved or absorbed in the reaction of 233.0 g of calcium oxide with enough carbon to produce calcium carbide? Is the process exothermic or endothermic?



15. (8.78) Sulfuric acid ( $\text{H}_2\text{SO}_4$ ), the most widely produced chemical in the world, is made by a two-step oxidation of sulfur to sulfur trioxide,  $\text{SO}_3$ , followed by reaction with water. Calculate  $\Delta H^\circ_f$  for  $\text{SO}_3$  in kJ/mol, given the following data:



16. (8.79) Calculate  $\Delta H^\circ_f$  in kJ/mol for benzene,  $\text{C}_6\text{H}_6$ , from the following data:

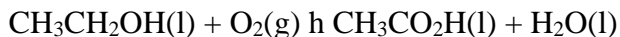


$$\Delta H^\circ_f(\text{CO}_2) = -393.5 \text{ kJ/mol} \quad \Delta H^\circ_f(\text{H}_2\text{O}) = -285.8 \text{ kJ/mol}$$

17. (8.80) The standard enthalpy change for the reaction of  $\text{SO}_3(\text{g})$  with  $\text{H}_2\text{O}(\text{l})$  to yield  $\text{H}_2\text{SO}_4(\text{aq})$  is  $\Delta H^\circ = -227.8 \text{ kJ}$ . Using information given in problem 14, calculate  $\Delta H^\circ_f$  for  $\text{H}_2\text{SO}_4(\text{aq})$  in kJ/mol.

$$[\text{For } \text{H}_2\text{O}(\text{l}), \Delta H^\circ_f = -285.8 \text{ kJ/mol}]$$

18. (8.81) Acetic acid ( $\text{CH}_3\text{CO}_2\text{H}$ ), whose aqueous solutions are known as vinegar, is prepared by reaction of ethyl alcohol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) with oxygen:



Use the following data to calculate  $\Delta H^\circ$  in kilojoules for the reaction:

$$\Delta H^\circ_f[\text{CH}_3\text{CH}_2\text{OH}(\text{l})] = -277.7 \text{ kJ/mol}$$

$$\Delta H^\circ_f[\text{CH}_3\text{CO}_2\text{H}(\text{l})] = -484.5 \text{ kJ/mol}$$

$$\Delta H^\circ_f[\text{H}_2\text{O}(\text{l})] = -285.8 \text{ kJ/mol}$$

19. (8.83) Methyl *tert*-butyl ether (MTBE),  $\text{C}_5\text{H}_{12}\text{O}$ , a gasoline additive used to boost octane ratings, has  $\Delta H^\circ_f = -313.6 \text{ kJ/mol}$ . Write a balanced equation for the combustion reaction and calculate the standard heat of combustion in kilojoules.

20. (8.84) Methyl *tert*-butyl ether is prepared by reaction of methanol(l) ( $\Delta H^\circ_f = -239.2 \text{ kJ/mol}$ ) with 2-methylpropene(g).



Calculate  $\Delta H^\circ_f$  in kJ/mol for 2-methylpropene.

21. (8.85) One possible use for the cooking fat left over after making French fries is to burn it as fuel. Write a balanced equation, and use the following data to calculate the amount of energy released in kJ/mL from the combustion of cooking fat:

$$\text{Formula} = \text{C}_{51}\text{H}_{88}\text{O}_6 \quad \text{Density} = 0.94 \text{ g/mL} \quad \Delta H_f^\circ = -1310 \text{ kJ/mol}$$

22. (8.102) Tell whether reactions with the following values of  $\Delta H$  and  $\Delta S$  are spontaneous or nonspontaneous and whether they are exothermic or endothermic:

- a.  $\Delta H = -48\text{kJ}$ ;  $\Delta S = +135 \text{ J/K @ } 400 \text{ K}$
- b.  $\Delta H = -48\text{kJ}$ ;  $\Delta S = -135 \text{ J/K @ } 400 \text{ K}$
- c.  $\Delta H = +48\text{kJ}$ ;  $\Delta S = +135 \text{ J/K @ } 400 \text{ K}$
- d.  $\Delta H = +48\text{kJ}$ ;  $\Delta S = -135 \text{ J/K @ } 400 \text{ K}$