Chapter 6 (Thermochemistry)

1. If a reaction is endothermic, then the: (a) reaction liberates heat (b) enthalpy of the reactants is higher than the enthalpy of the products (c) reaction cannot occur (d) enthalpy difference between products and reactants ($\Delta H$) is positive (e) temperature will increase if the reaction occurs in a calorimeter

2. Which of the following chemical equations correctly represents the reaction in which the standard molar heat of formation of CO$_2$ is liberated? (a) C(g) + O$_2$(g) $\rightarrow$ CO$_2$(g) (b) 2CO(g) + O$_2$(g) $\rightarrow$ 2CO$_2$(g) (c) C(s) + O$_2$(g) $\rightarrow$ CO$_2$(g) (d) C(s) + 2O(g) $\rightarrow$ CO$_2$(g)

3. What is the enthalpy change for the following reaction at standard conditions?

\[
\text{SO}_2(g) + 3 \text{H}_2(g) \rightarrow \text{H}_2\text{S}(g) + 2 \text{H}_2\text{O}(l)
\]

$\Delta H_{\text{r}}$ $\text{SO}_2(g)$ = -71.0 kcal/mole , $\Delta H_{\text{r}}$ $\text{H}_2\text{S}(g)$ = -4.8 kcal/mole , $\Delta H_{\text{r}}$ $\text{H}_2\text{O}(l)$ = -68.3 kcal/mole.

4. Calculate the enthalpy change for the reaction: $2\text{NaBr}(s) + \text{I}_2(s) \rightarrow 2\text{NaI}(s) + \text{Br}_2(g)$

Use the following data:

$\text{Na}(s) + \frac{1}{2} \text{Br}_2(l) \rightarrow \text{NaBr}(s)$ \hspace{1cm} $\Delta H = -86$ kcal

$\text{Na}(s) + \frac{1}{2} \text{I}_2(s) \rightarrow \text{NaI}(s)$ \hspace{1cm} $\Delta H = -68.8$ kcal

$\text{Br}_2(l) \rightarrow \text{Br}_2(g)$ \hspace{1cm} $\Delta H = 7.4$ kcal

5. Calculate the Enthalpy change for: $2\text{B}(s) + 3\text{H}_2(g) \rightarrow \text{B}_2\text{H}_6(g)$ given:

\[
2\text{B}(s) + \frac{3}{2} \text{O}_2(g) \rightarrow \text{B}_2\text{O}_3(s) \hspace{1cm} \Delta H = -1273$ kJ

$\text{B}_2\text{H}_6(g) + 3\text{O}_2(g) \rightarrow \text{B}_2\text{O}_3(s) + 3\text{H}_2\text{O}(g)$ \hspace{1cm} $\Delta H = -2035$ kJ

$\text{H}_2(g) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(l)$ \hspace{1cm} $\Delta H = -286$ kJ

$\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g)$ \hspace{1cm} $\Delta H = 44$ kJ

6. $\text{CH}_4 + 4\text{Cl}_2 \rightarrow \text{CCl}_4 + 4\text{HCl}$ \hspace{1cm} $\Delta H_{\text{rxn}} = -4.34 \times 10^5$ J

Based on the above reaction, what would be the energy change is 32 g of $\text{CH}_4$ reacted with an excess of chlorine? Is the energy absorbed or released?

7. $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$ \hspace{1cm} $\Delta H = -92.2$ kJ

What is $\Delta E$? (reaction is carried out at constant P and 40 atm. Also, $\Delta V = -1.12 L$.)

8. A balloon is inflated to its full extent by heating the air inside it. In the final stages of this process, the volume of the balloon changes from $4.00 \times 10^6$ L to $4.5 \times 10^6$ L by the addition of $1.3 \times 10^8$ J of energy as heat. Assuming that the balloon expands against a constant pressure of 1.0 atm, calculate $\Delta E$ for the process. (to convert between L.atm and J, use 1 L.atm = 101.3 J.)
9. A 0.5269 g sample of octane (C₈H₁₈) is burned in a bomb calorimeter with a known heat capacity of 11.3 kJ/°C. The temperature increase in the calorimeter is 2.25°C. How much heat was released? How much heat would be released if one mole of octane is combusted? (this problem omitted in 2004)

10. A student mixed 50 ml of 1 M HCl and 50 ml of 1 M NaOH in a coffee-cup calorimeter. The solution temperature increases from 21°C to 27.5°C. Calculate the enthalpy change for the reaction assuming that the lost of heat by the calorimeter is negligible, the total volume is 100 ml, the density of the solution is 1.0 g/ml, and the specific heat of the solution is 4.18 J/g-K. What is the enthalpy change per mole of HCl or NaOH?

11. A 15 g sample of nickel is heated to 100°C and dropped into a 55 g of water, initially at 23°C. Assuming that all of the heat lost by the nickel is absorbed by the water, calculate the final temperature of the nickel and water. (Specific heat of nickel is 0.444 J/°C g, Specific Heat of water is 4.18 J/°C g)

Chapter 7 (Electronic Structure and Atoms)

Electromagnetic Radiation

12. What is the wavelength of an infrared wave whose velocity is 3 X 10¹⁰ cm/s and whose frequency is 9 X 10¹¹ s⁻¹?

13. What is the minimum wavelength of a photon of light that can excite an electron in the hydrogen atom from n = 1 to n = 8 energy level?

14. What is the minimum wavelength of a photon of light that can ionize an electron from the n = 2 level in the hydrogen atom? What is the Energy of a photon of this radiation?

15. If an electron has a mass of 9.11 X 10⁻²⁸ g, what is its wavelength if it is traveling at a rate of 8 X 10⁷ cm/s.

Quantum Numbers and Electron Configurations

16. Write the electron configuration of Mn using three forms.

17. Write the electron configuration for Cu and Cr.

18. Write the electron configuration for Zr²⁺ and O²⁻.

19. How many electrons in the outer energy level (or how many valence electrons) in S and V?
20. What are the highest and lowest energy electrons in Sc?

21. What is the difference in ground state and excited state configuration? Write an impossible electron configuration.

22. Tell if these violate Hund’s Rule or Pauli Exclusion Principle. Which is ground state and which is excited state.

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(b) \[
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23. How many electrons can have the quantum numbers n = 3, l = 1, m_l = 1?

24. Which list is an allowable set of quantum numbers (they are in the order of n,l,m_l, s). (a) 1, 1, 1, 1/2  (b) 2, 3, -2, 1/2  (c) 3, 2, -1, -1/2  (d) 4, 2, -3, -1/2

25. What is/are the possible magnetic quantum number (m_l) for the highest energy electron in a ground state aluminum atom?

26. In the group (a), which has the greatest ionization energy, electron affinity, and electronegativity: (a) Al, P, O. For groups (b) & (c), which has the greatest ionization energy (b) C, N, O  (c) Li, Be, B

27. In each group of three, which is the largest atom:  (a) O, K, Rb  (b) C, F, Br

Extra Questions:

28. Place the following regions of the electromagnetic spectrum in order of increasing wavelength: blue light, X rays, infrared light, orange light, gamma rays, microwaves.

29. What is the wavelength of a radio signal from KSCS FM operating at a frequency of 96.3 MHz?

30. What is the ground state configuration of radon (Rn, number 86)
Facts to Memorize

Generally, the closer an element is to F on the periodic table, the greater the trend except for size.

Exothermic (heat given off) $\Delta H$ or $q$ is negative
Endothermic (heat taken in) $\Delta H$ or $q$ is positive

Work is done on the system $w$ is positive
Work is done on the surroundings $w$ is negative

$\Delta E = q + w$ (heat plus work)
$w = -P\Delta V$

$\Delta E = q - P\Delta V$ (if the work done is the expansion of a gas)

$H$ (enthalpy) for elements in natural state = 0

Heat = (specific heat)(mass)(\Delta T)
Heat gained = heat lost (in a perfectly insulated system)

Magnetic quantum number is $m$, angular momentum number is $l$, and principal quantum number is $n$, spin number is $s$.

Allowed Values:
- $n = 1,2,3, \ldots$ whole numbers
- $l = n-1$ decreasing down to zero
- $m = l$ to $-l$ ($l = 0$ is $s$, $l = 1$ is $p$, $l = 2$ is $d$, $l = 3$ is $f$)
- $s = 1/2$ or $-1/2$

Equations:

$\Delta H_{\text{rxn}} = \Delta H_{\text{prod}} - \Delta H_{\text{reactants}}$
$\Delta E = q + w = q - P\Delta V$

$E = \Delta T(\text{heat capacity})$
$q = (\text{sp heat})(\text{mass})(\Delta T)$

- heat lost = heat gained

$v = c/\lambda$

$\Delta E = -2.178 \times 10^{-18}$ J$[1/n_{\text{F}}^2 - 1/n_{\text{i}}^2]$

$E = hv = hc/\lambda$

$\lambda = h/mv$

$J = \text{Kg m}^2/\text{s}^2$