Exercise #1 (homework)

1) Represent the electronic structure of Bromine (Br, Z=35).

2) Write the complete electronic configuration of Sulfur (S).

3) Write the complete electronic configuration of the following atoms:

a) N b) O c) Na d) K e) V f) Br

4) Assign the quantum numbers n and l to the following orbitals:

2p 1s 3p 3d 5f 4d

5) Write the symbols for the orbitals characterized by the following pairs of values (n, l):

(2, 0) (3, 1) (5, 3) (2, 1) (4, 2) (1, 0)

6) Cesium (Cs) ionizes easily. The most easily ionized electron comes from the level:

a) 6p b) 5d c) 6s d) 4f

7) Which of the following atoms is the largest?

a) K b) Ca c) Li d) Mg

8) Which of the following elements loses an electron most easily?

a) Si b) Mg c) Na d) Al

9) Down a group in the periodic table (from top to bottom), the ionization potential:
a) decreases progressively b) increases progressively c) remains almost constant d) decreases in the first two groups, increases progressively in groups three and onward

10) Indicate the names of the elements that have the following electronic configuration:

a) $1s^2\ 2s^2\ 2p^2$ b) [Ar] $3d^1\ 4s^2$ c) [Ar] $3d^{10}\ 4s^2\ 4p^2$ d) [Kr] $4d^2\ 5s^2$

11) Write the electronic configuration of the following ions:

a) Cl^- b) Na^+ c) Al^{3+} d) O_2^- e) Li^+

12) Which of the following diatomic molecules have multiple bonds (double and triple bonds), and indicate the number of σ and π bonds that characterize each of these molecules.

F_2 N_2 O_2 Cl_2 H_2 Br_2

13) Describe the formal charge and any resonance structures for the following species:

a) PO_4^{3-} b) SO_4^{2-} c) NH_4^+

14) Which of the following molecules are polar:

a) BCl_3 b) CH_3Cl c) HCl d) CO e) SF_6

15) For the following compounds: a) draw the Lewis structure, b) describe the type of hybridization the central atom has, c) represent the molecular geometry according to VSEPR theory.

a) BCl_3 b) PCl_3 c) CH_4 d) BrF_5 e) SF_4

Exercise #2 (homework)

1) Write the formulas and balance the following:

a. Calcium Hydrogen Carbonate → Calcium Carbonate + Water + Carbon Dioxide

b. Lead(II) Sulfide + Oxygen → Lead(II) Oxide + Sulfur Dioxide

c. Tin(IV) Oxide + Carbon → Tin + Carbon Monoxide

d. Mercury(I) Hydroxide + Hydrogen Sulfide → Mercury(I) Sulfide + Water

2) Write the formulas and balance the following reactions after completing them with the appropriate reactants or products.

a. Orthophosphorous Acid + Copper(II) Oxide → .....

b. Lead(IV) Oxide + Carbon Dioxide → .....

c. ..... → Calcium Carbonate

d. ..... → Calcium Sulfate + Hydrofluoric Acid

3) Given the following double displacement reaction:

$$BaCl_2 + K_2SO_4 \rightarrow KCl + \mathbf{X}$$

a) Complete the transformation by identifying the formula for compound **X** and balance the chemical equation.

b) Assign the appropriate name to each species present in the chemical equation.

c) How many grams of compound **X** are formed starting from 8 grams of $BaCl_2$? How many grams of K_2SO_4 are required to complete this transformation?

(Atomic Masses: Ba = 137; Cl = 35.5; K = 39; S = 32; O = 16)

4) Write the formulas and balance the following:

a. Sodium Carbonate + Calcium Hydroxide → Sodium Hydroxide + Calcium Carbonate

b. Silver Nitrate + Ferric Chloride → Silver Chloride + Ferric Nitrate

c. Hydrogen Sulfide + Lead(II) Hydroxide → Lead(II) Sulfide + Water

d. Sulfur Dioxide + Sodium Hydroxide → Sodium Sulfite + Water

e. Potassium Hydrogen Sulfite + Hydrochloric Acid → Sulfurous Acid + Potassium Chloride

5) Given the following reaction:

$Na_2SO_4 + Cr(OH)_3 \rightarrow NaOH + Cr_2(SO_4)_3$

a) Balance the chemical equation and assign the appropriate name to each species present.

b) By reacting 34.08 g of Na_2SO_4 with 18.54 g of $Cr(OH)_3$, how many grams of $Cr_2(SO_4)_3$ are formed?

c) Which reactant and in what quantity remains in excess at the end of the reaction?

(Molar Masses: Na_2SO_4 142 g/mol, $Cr(OH)_3$ 103 g/mol, $Cr_2(SO_4)_3$ 392 g/mol)

Exercise #3 (homework)

1) How many grams of Zn must be dissolved in sulfuric acid to obtain 500 mL of hydrogen at 20°C and 770 mmHg? (Hydrogen gas and zinc sulfate are formed in the reaction.)

[1.37 g]

2) Calculate the pressure in a 97.15 L vessel containing 1.56 g of carbon dioxide at 44 °C. Repeat the calculation considering 1.56 kg of carbon dioxide.

[9.5×10^{-3} atm; 9.5 atm]

3) A 30 L cylinder contains methane (CH_4) at a pressure of 150 atm and a temperature of 20 °C. Calculate how many grams of methane remain in the cylinder after some gas has been released so that the pressure is halved.

[1500 g]

4) A 5 L vessel at 0°C contains 15 g of sulfur dioxide and 8 g of oxygen. Calculate the pressure of the mixture.

[2.171 atm]

5) A gaseous mixture has the following mass composition: 25% (w/w) N_2 and 75% (w/w) H_2. Knowing that the total pressure is 5 atm, calculate the partial pressure of each gas.

[N_2 = 0.115 atm; H_2 = 4.885 atm]

6) To "absorb" the carbon dioxide exhaled by astronauts during short missions, lithium oxide can be used, one of the most efficient substances in terms of absorption capacity per unit mass.

$$Li_2O + CO_2 \rightarrow Li_2CO_3$$

Calculate how many kilograms of lithium oxide are needed to absorb 1000 liters of CO_2 measured at 25°C and 1 atm.

[1.23 kg]

Exercise #4 (homework)

1) Determine the enthalpy change at 25°C and 1 atm for the combustion of methane, knowing that the standard enthalpies of formation for $CH_4(g)$, $CO_2(g)$, and $H_2O(l)$ are -75 kJ/mol, -394 kJ/mol, and -286 kJ/mol, respectively.

[-891 kJ/mol]

2) Calculate the standard enthalpy of the following reaction:

A) $N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$ $\quad \Delta H°_A = ?$

Given the following reactions and standard enthalpies:

B) $NO_{(g)} \rightarrow ½\ N_{2(g)} + ½\ O_{2(g)}$ $\quad \Delta H°_B = -90.3$ kJ

C) $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(l)}$ $\quad \Delta H°_C = -286.0$ kJ

D) $4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(l)}$ $\quad \Delta H°_D = -1170.4$ kJ

[-92.2 kJ/mol]

3) Ammonia, when burned, produces nitrogen monoxide according to the following reaction:

$$NH_{3(g)} + O_{2(g)} \rightarrow NO_{(g)} + H_2O_{(g)}$$

a) Balance the reaction

b) Determine the $\Delta H°$ of this transformation

c) Calculate the heat released by the combustion of 42 grams of NH_3

($\Delta H°_f\ [H_2O_{(g)}] = -242.00\ kJ \cdot mol^{-1}$; $\Delta H°_f\ [NH_{3(g)}] = -46.05\ kJ \cdot mol^{-1}$; $\Delta H°_f\ [NO_{(g)}] = +90.40\ kJ \cdot mol^{-1}$)

[b) -906.2 kJ; c) -559.58 kJ]

4) Calculate the standard Gibbs free energy change (ΔG°) at 120°C for the following reaction:

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(g)$$

Given:

$\Delta H°_f (NH_4NO_3) = -365.6$ kJ/mol

$\Delta S°_f (NH_4NO_3) = 151.1$ J/mol·K

$\Delta H°_f (N_2O) = 82.1$ kJ/mol

$\Delta S°_f (N_2O) = 219.9$ J/mol·K

$\Delta H°_f (H_2O_{(g)}) = -241.8$ kJ/mol

$\Delta S°_f (H_2O_{(g)}) = 188.8$ J/mol·K

and that ΔH° and ΔS° can be considered constant in the temperature range 25–120°C.

[-211.33 kJ/mol]

5) Calculate the standard Gibbs free energy change (ΔG°) at 25°C for the following reaction:

$$4HCl_{(g)} + O_{2\,(g)} \rightarrow 2Cl_{2\,(g)} + 2H_2O_{\,(l)}$$

Given:

$\Delta H°_f (HCl_{(g)}) = -92.3$kJ/mol

$\Delta S°_f (HCl_{(g)}) = 186.9$ J/mol K

$\Delta S°_f (O_2) = 205.2$ J/mol K

$\Delta S°_f (Cl_2) = 223.1$ J/mol K

$\Delta H°_f (H_2O_{(l)}) = -285.8$kJ/mol

$\Delta S°_f (H_2O_{(l)}) = 70.0$ J/mol K

[-93.2kJ/mol]

6) Calculate the ΔG° at 230°C for the reduction of one mole of solid Fe_2O_3 with gaseous hydrogen; the products are metallic iron and water vapor.

(($\Delta H°_f$ for $H_2O_{(g)}$ is -241.8 kJ/mol; for $Fe_2O_{3(s)}$ is -824.2 kJ/mol; ΔS° for $H_2O_{(g)}$ is 188.7 J/mol·K; for $Fe_{(s)}$ is 27.0 J/mol·K; for $H_{2(g)}$ is 130.6 J/mol·K; for $Fe_2O_{3(s)}$ is 87.4 J/mol·K).

[27.93 kJ/mol] [27.93kJ/mol]

Exercise #5 (homework)

1) 7 g of PCl_5 are introduced into a 7 L container and the temperature is kept constant at 30 °C. After some time, once equilibrium is reached, the measured pressure is 0.151 atm. Calculate the value of Kp for the reaction:

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

[Atomic weights: P = 30.97 g/mol; Cl = 35.45 g/mol]

[Kp = 0.0114]

2) Given that the reaction

$$C_2H_4\,(g) + H_2O\,(l) \rightleftharpoons C_2H_6O\,(l)$$

has $\Delta H° = -9.9$ kcal/mol and $\Delta S° = -30$ cal/K·mol, calculate the value of $\Delta G°$ and determine whether the reaction is spontaneous at 25°C.

Also, calculate the equilibrium constant K.

[yes; K = 5.1]

3) 3.12 moles of iodine and 9.44 moles of hydrogen are heated to a temperature of 720 K and, once equilibrium is reached, the reaction mixture contains 5.96 moles of hydrogen iodide. Write and balance the reaction and calculate the equilibrium constant.

[K = 39.28]