Assignment 05 A

1- Calculate the kinetic energy of a 7.3-kg steel ball traveling at 18.0 m/s.
   a) 66 J
   b) 4.8 x 10^3 J
   c) 1.2 x 10^3 J
   d) 2.4 x 10^3 J

   *(The kinetic energy is equal to one-half the product of the mass (in kg) and the velocity (in m/s)^2.)*

2- According to the first law of thermodynamics,
   a) the amount of work done during a change is independent of the pathway of that change.
   b) the entropy of a pure, crystalline substance at absolute zero is zero.
   c) energy is conserved during any process.
   d) all spontaneous processes are accompanied by an increase in disorder.
   e) none of these.

   *(The first law says that energy is neither created nor destroyed.)*

3- Given the thermochemical equation 2NO(g) + O_2(g) → 2NO_2(g) \( \Delta H^\circ = -114.0 \text{ kJ} \),
   calculate \( \Delta H^\circ \) for the following reaction: NO_2(g) → NO(g) + 1/2O_2(g)
   a) +57.00 kJ
   b) −57.00 kJ
   c) −114.0 kJ
   d) +114.0 kJ

   *(One-half of the \( \Delta H^\circ \) for the reverse reaction gives the \( \Delta H^\circ \) of this reaction.)*

4- Which one of the following is true concerning enthalpy?
   a) The enthalpy change of a reaction is the inverse of the enthalpy change of the reverse reaction.
   b) It is an intensive property, always having the units energy per mole.
   c) It usually is largely different in magnitude than the internal energy change of a process.
   d) It is a state function.
   e) It is measured under conditions of constant volume.

   *(The enthalpy change is dependent only on the initial and final states.)*

5- A 2.839-g sample of C_2H_4O was burned in a bomb calorimeter with a total heat capacity of 16.77 kJ/°C. The temperature of the calorimeter increases from 22.62°C to 26.87°C. What is the heat of combustion per mole of C_2H_4O?
   a) −61.2 kJ/mol
   b) −1.10 x 10^3 kJ/mol
   c) −3.93 kJ/mol
   d) −3.14 x 10^3 kJ/mol
   e) −8.90 x 10^3 kJ/mol
   f) −260. kJ/mol

   *(The total heat is obtained by multiplying the total heat capacity by the temperature change. The molar heat of combustion is then obtained by dividing the heat by the number of moles that produced the heat. Since the reaction is exothermic, heat is given off.)*

6- The specific heat of lead is 0.13 J/g-K. How many joules of heat would be required to raise the temperature of 15 g of lead from 22°C to 37°C?
   a) 29 J
   b) −0.13 J
   c) 2.0 J
   d) 5.8 x 10^{-4} J
(The heat is equal to the product of specific heat capacity, temperature rise, and mass.)

7- From the following enthalpies of reaction,
\[ \text{H}_2(g) + \text{F}_2(g) \rightarrow 2\text{HF}(g) \quad \Delta H = -537 \text{kJ} \]
\[ \text{C}(s) + 2\text{F}_2(g) \rightarrow \text{CF}_4(g) \quad \Delta H = -680. \text{kJ} \]
\[ 2\text{C}(s) + 2\text{H}_2(g) \rightarrow \text{C}_2\text{H}_4(g) \quad \Delta H = +52.3 \text{kJ} \]
calculate \( \Delta H \) for the reaction of ethylene with \( \text{F}_2 \):
\[ \text{C}_2\text{H}_4(g) + 6\text{F}_2(g) \rightarrow 2\text{CF}_4(g) + 4\text{HF}(g) \]
a) \(-1165 \text{kJ}\)
b) \(+234 \text{kJ}\)
c) \(-2486 \text{kJ}\)
d) \(-1269 \text{kJ}\)
e) \(-2382 \text{kJ}\)

(This is twice the \( \Delta H \) for equation 3.)

8- Calculate the standard enthalpy of formation of solid \( \text{SrCO}_3 \), given the following data:
\[ 2\text{Sr}(s) + \text{O}_2(g) \rightarrow 2\text{SrO}(s) \quad \Delta H = -1184 \text{kJ} \]
\[ \text{SrO}(s) + \text{CO}_2(g) \rightarrow \text{SrCO}_3(s) \quad \Delta H = -234 \text{kJ} \]
\[ \text{C}(\text{graphite}) + \text{O}_2(g) \rightarrow \text{CO}_2(g) \quad \Delta H = -394 \text{kJ} \]
a) \(-1812 \text{kJ/mol}\)
b) \(-628 \text{kJ/mol}\)
c) \(-826 \text{kJ/mol}\)
d) \(-234 \text{kJ/mol}\)
e) \(-1220. \text{kJ/mol}\)

(One-half of the first reaction plus the other two reactions as written gives the desired overall formation reaction. Halve the heat from the first reaction and add this to the enthalpy changes for the other two reactions.)

9- Which of the following changes always results in a negative \( \Delta E \)?
   a) The system absorbs heat and does work.
   b) The system absorbs heat and has work done on it.
   c) The system gives off heat and does work.
   d) The system gives off heat and has work done on it.

(The sign of both heat and work is negative. Their sum will always be negative.)

10- For a process in which the internal energy does not change, which of the following are possible?
(i) heat > 0, work < 0
(ii) heat > 0, work > 0
(iii) heat < 0, work < 0
(iv) heat < 0, work > 0

a) ii and iv only
b) i and ii only
c) i and iii only
d) ii and iii only
e) i and iv only
f) iii and iv only

(Since the change in internal energy is equal to zero, the sign for the heat must be opposite to the sign for the work.)

11- Which of the following quantities —heat, work, enthalpy, internal energy— depend only on the end points and not on the path followed in a process?
a) heat
b) work
c) enthalpy and internal energy
d) enthalpy
e) internal energy

(Enthalpy and internal energy are state functions and do not depend upon the path.)

12- When 0.215 mol NH₃ is formed from nitrogen and hydrogen, 9.91 kJ of energy is released as heat. Assuming constant pressure is maintained, what is the ΔH for this reaction per mole of NH₃ formed?
   a) −9.91 kJ
   b) 46.1 kJ
   c) 9.91 kJ
   d) −2.13 kJ
   e) −46.1 kJ

(The enthalpy change for the reaction (−9.91 kJ) was divided by the number of moles to determine the ΔH per mole.)

13- When heat is absorbed by the system from the surroundings, the process is said to be ____________, and the sign of q is ____________.
   a) endothermic, positive
   b) exothermic, positive
   c) exothermic, negative
   d) endothermic, negative

(A process is endothermic if the system absorbs heat, and the sign of q would be positive relative to the system.)

14- An endothermic reaction is carried out in a coffee-cup calorimeter. Which statement is incorrect for this process?
   a) The products have higher enthalpy than the reactants.
   b) Heat is absorbed from the water.
   c) The temperature of the water decreases.
   d) The enthalpy change for the reaction is positive.
   e) The enthalpy change for the reaction is equal to q_H2O.

(This answer is an incorrect statement. The enthalpy change for the reaction is not equal to the heat flow with regards to water; it is equal to the negative of the heat.)

15- A volume of 50.0 mL of 0.400 M HBr at 24.35°C is added to 50.0 mL of 0.400 M NaOH, also at 24.35°C. The final temperature is 27.06°C. Calculate the enthalpy change, ΔH, in kJ for the following reaction:
   \[ \text{HBr(aq) + NaOH(aq) → NaBr(aq) + H}_2\text{O(l)} \]
   (Heat capacity of the system is 0.418 kJ/°C.)
   a) −324 kJ
   b) −28.4 kJ
   c) −56.7 kJ
   d) −113 kJ

(The heat capacity times the temperature rise gives the heat. Dividing by the number of moles of one of the reactants gives the enthalpy change of the reaction. Since the reaction is exothermic, the enthalpy change is negative.)

16- Natural gas is composed primarily of
   a) propane.
   b) methane.
   c) butane.
(Natural gas is primarily composed of methane, but also contains small amounts of ethane, propane, and butane, but primarily methane.)

17- The fuel used in spacecraft must contain as much energy per gram of material as possible. Based on this consideration only, which of the following fuels is best suited to be a spacecraft fuel?

- (i) dimethylhydrazine, \((CH_3)_2NNH_2\) \(\Delta H_{\text{combustion}} = -1694 \text{ kJ/mol}\)
- (ii) methanol, \(\text{CH}_3\text{OH}\) \(\Delta H_{\text{combustion}} = -726 \text{ kJ/mol}\)
- (iii) ethanol, \(\text{C}_2\text{H}_5\text{OH}\) \(\Delta H_{\text{combustion}} = -1371 \text{ kJ/mol}\)
- (iv) octane, \(\text{C}_8\text{H}_{18}\) \(\Delta H_{\text{combustion}} = -5500 \text{ kJ/mol}\)
- (v) ethylene glycol, \(\text{C}_2\text{H}_6\text{O}_2\) \(\Delta H_{\text{combustion}} = -1190 \text{ kJ/mol}\)

a) Octane  
b) Methanol  
c) Ethylene glycol  
d) Ethanol  
e) Dimethylhydrazine

(18- Use the \(\Delta H\) values for equations 1 and 2 to determine the value of \(\Delta H\) for equation 3.

1) \(2\text{NO} \rightarrow \text{N}_2 + \text{O}_2\) \(\Delta H = -180. \text{ kJ}\)
2) \(2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2\) \(\Delta H = -112 \text{ kJ}\)
3) \(\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2\) \(\Delta H = ?\)

a) \(-292 \text{ kJ}\)  
b) \(-68 \text{ kJ}\)  
c) \(-68 \text{ kJ}\)  
d) \(292 \text{ kJ}\)

(The enthalpy change of the second reaction minus the enthalpy change of the first reaction gives the enthalpy change of the desired reaction.)

19-

<table>
<thead>
<tr>
<th>Substance</th>
<th>(\Delta H_f^\circ) (kJ/mol)</th>
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<tbody>
<tr>
<td>(\text{SO}_2(g))</td>
<td>-297</td>
</tr>
<tr>
<td>(\text{SO}_3(g))</td>
<td>-396</td>
</tr>
<tr>
<td>(\text{SO}_2\text{Cl}_2(g))</td>
<td>-364</td>
</tr>
<tr>
<td>(\text{H}_2\text{SO}_4(l))</td>
<td>-814</td>
</tr>
<tr>
<td>(\text{H}_2\text{O}(l))</td>
<td>-286</td>
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</table>

Determine the value of in kJ for the following reaction: \(2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)\)

a) 198 kJ  
b) 99 kJ  
c) \(-198 \text{ kJ}\)  
d) \(-99 \text{ kJ}\)

(The \(\Delta H_f^\circ\) for the formation of 2 moles of \(\text{SO}_3(g)\) minus the \(\Delta H_f^\circ\) for the formation of 2 moles of \(\text{SO}_2(g)\) gives \(\Delta H_f^\circ\) for the reaction.)

20- Consider the reaction

\[
\text{Pb}^{2+}(aq) + 2\text{Cl}^-(aq) \rightarrow \text{PbCl}_2(s) \quad \Delta H = -22.53 \text{ kJ/mol}
\]

Calculate \(\Delta H\) when 0.230 mol of \(\text{PbCl}_2(s)\) is dissolved in water.
21- From the following heats of reaction,
\[ \text{2C(graphite) + H}_2(g) \rightarrow C_3H_2(g) \quad \Delta H^\circ = 227 \text{ kJ} \]
\[ \text{6C(graphite) + 3H}_2(g) \rightarrow C_6H_6(l) \quad \Delta H^\circ = 49 \text{ kJ} \]
calculate the \( \Delta H^\circ \) for the reaction
\[ C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H^\circ = -1367 \text{ kJ} \]
\[ H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \quad \Delta H^\circ = -286 \text{ kJ} \]
\[ \text{C(graphite) + O}_2(g) \rightarrow CO_2(g) \quad \Delta H^\circ = -394 \text{ kJ} \]
(Hess's law was used; 3 times the reverse of the first reaction was added to the second reaction.)

22- The standard heat of combustion of fructose, C\(_6\)H\(_{12}\)O\(_6\)(s), is −2812 kJ/mol. Calculate \( \Delta H_f^\circ \) for fructose.
The standard molar enthalpies of formation you will need are:
\[ \text{CO}_2(g) = -393.5 \text{ kJ/mol.} \]
\[ \text{H}_2O(l) = -285.8 \text{ kJ/mol.} \]
a) +2133 kJ/mol.
b) 210.3 kJ/mol.
c) 1264 kJ/mol.
d) −999.8 kJ/mol.
e) −210.3 kJ/mol.
f) −1264 kJ/mol.
(The standard heat of reaction is equal to the sum of the total standard enthalpy of formation of products minus the total standard enthalpy of formation of reactants.)

23- Use the following thermochemical equations:
\[ C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H^\circ = -1367 \text{ kJ} \]
\[ H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \quad \Delta H^\circ = -286 \text{ kJ} \]
\[ \text{C(graphite) + O}_2(g) \rightarrow CO_2(g) \quad \Delta H^\circ = -394 \text{ kJ} \]
to calculate the standard enthalpy of formation for the following reaction:
\[ 2C(g) + 3H_2(g) + 1/2O_2(g) \rightarrow C_2H_5OH(l) \quad \Delta H_f^\circ = ? \]
a) +279 kJ/mol.
b) −279 kJ/mol.
c) +680 kJ/mol.
d) +2047 kJ/mol.
e) +687 kJ/mol.
(The reverse of the first reaction added to three times the second reaction and twice the third gives the correct overall reaction and enthalpy change.)

24- Which one of the following reactions has a positive value of \( \Delta H^\circ \)?
a) \( \text{CO}_2(g) \rightarrow \text{CO}_2(s) \)
b) \( \text{NH}_3(g) \rightarrow \text{NH}_3(l) \)
c) \( 2\text{H}_2\text{O}(l) \rightarrow 2\text{H}_2(g) + \text{O}_2(g) \)
d) \( \text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) \)
(Decomposing water to its elements requires considerable amounts of energy, and it is therefore endothermic ($\Delta H^\circ > 0$).)

25- The value of $\Delta H^\circ$ for the following reaction is $-126$ kJ. Determine the amount of heat (in kJ) that would be evolved by the reaction of 25.0 g of Na$_2$O$_2$ with water. $2\text{Na}_2\text{O}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow 4\text{NaOH}(s) + \text{O}_2(g)$

a) 80.8 kJ evolved  
b) 197 kJ evolved  
c) 20.2 kJ evolved  
d) 40.4 kJ evolved

(The heat was found by multiplying the number of moles in 25.0 g of Na$_2$O$_2$ by the enthalpy change per mole of Na$_2$O$_2$.)

26- For which one of the following reactions is the value of $\Delta H^\circ$ not equal to $\Delta H_f^\circ$ for the product?

a) $\text{C}(s) + 1/2\text{O}_2(g) \rightarrow \text{CO}(g)$

b) $3\text{Mg}(s) + \text{N}_2(l) \rightarrow \text{Mg}_3\text{N}_2(s)$

c) $\text{Ca}(s) + 1/2\text{O}_2(g) \rightarrow \text{CaO}(s)$

d) $2\text{C}(s) + 2\text{H}_2(g) \rightarrow \text{C}_2\text{H}_4(g)$

(Nitrogen is not in its standard state; therefore, the standard heat of formation does not equal the enthalpy of the reaction.)