15.1 Standard Enthalpy Changes of Reaction Study Worksheet

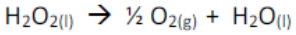
1. During the Apollo II project that landed the first man on the moon on July 21, 1969 it was decided that methyl hydrazine (CH_3NHNH_2) and dinitrogen tetroxide (N_2O) would be used as fuels. These two substances were chosen because they ignite spontaneously and are very exothermic when mixed:

$$4\ CH_3NHNH_2\ (l) + 5\ N_2O_4\ (l) \rightarrow 4\ CO_2\ (g) + 12\ H_2O\ (l) + 9\ N_2\ (g)$$

Calculate the enthalpy change for the reaction using the standard enthalpy change data provided.

Substance	$\Delta H_f^{\ominus}$ / kJmol^{-1}
CH_3NHNH_2 (l)	+53
N_2O_4 (l)	-20
CO_2 (g)	-393
H_2O (l)	-286

2. (N04Mod) The equation for the catalytic decomposition of hydrogen peroxide is given below.



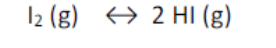
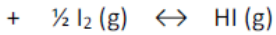
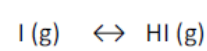
$$H_2O_{2(l)} \rightarrow \tfrac{1}{2}\ O_{2(g)} + H_2O_{(l)}$$

At 500K, ΔH for the reaction is -196 kJmol^{-1}.

a) Explain why ΔH for the reaction cannot be described as $\Delta H_f^{\ominus}$. [2]

b) What is the $\Delta H_f^{\ominus}$ of elemental oxygen? [1]

3. Which one of the following is not a "standard state" condition?
   A. Temperature = 298 K
   B. Pressure = 101.3 kPa
   C. All reactants and products are in their gaseous state
   D. All solutions are 1 mol dm^{-3}

4. The standard enthalpy of formation for hydrogen iodide is the enthalpy change for:
   A. 
   $H_2\ (g) + I_2\ (g) \leftrightarrow 2\ HI\ (g)$
   B. 
   $\tfrac{1}{2}\ H_2\ (g) + \tfrac{1}{2}\ I_2\ (g) \leftrightarrow HI\ (g)$
   C. 
   $H\ (g) + I\ (g) \leftrightarrow HI\ (g)$
   D.
   $H^+\ (g) + I^-\ (g) \leftrightarrow HI\ (g)$

5. Given the standard enthalpy of formation data the enthalpy change for the reaction below is:

$NaHCO_3$ = - 948 $kJmol^{-1}$; Na_2CO_3 = -1131 $kJmol^{-1}$; CO_2 = -395 $kJmol^{-1}$;
H_2O = - 286 $kJmol^{-1}$

$$2\ NaHCO_3\,(s) \rightarrow Na_2CO_3\,(s) + CO_2\,(g) + H_2O\,(l)$$

A. + 84 $kJmol^{-1}$
B. + 864 $kJmol^{-1}$
C. - 864 $kJmol^{-1}$
D. - 84 $kJmol^{-1}$

6. Write balanced equations for the following reactions and use standard enthalpy of formation data to calculate the enthalpy change associated with each:

a) zinc and chlorine reacting to form zinc chloride [3]
b) hydrogen sulfide and sulfur dioxide reacting to form sulfur and water. [3]
c) lead (II) nitrate decomposing to lead (II) oxide, nitrogen dioxide and oxygen. [3]
d) (HL) Draw a Lewis dot diagram for the nitrogen dioxide molecule and account for why the nitrogen-oxygen bond lengths are same [3]

[Standard enthalpy of formation data in $kJmol^{-1}$: $ZnCl_2$ = -416 ; H_2S = -21 ;
SO_2 = -297 ; H_2O = -286 ; $Pb(NO_3)_2$ = -449 ; PbO = -218 ; NO_2 = +34]

7. (M05) The standard enthalpy change for the combustion of phenol, $C_6H_5OH_{(s)}$ is - 3050 $kJmol^{-1}$ at 25ºC.
a) Write an equation for the combustion of phenol. [1]
b) The standard enthalpy changes of formation of carbon dioxide and water are -394 $Jmol^{-1}$ and -286 $kJmol^{-1}$ respectively. Calculate the enthalpy of formation of phenol. [3]