Darren's Thermochemistry WS Review Frenzy

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10/10/'24

1 Introduction

With the high amount of lower marks in Chemistry due to the recent Thermochemistry Worksheet made by yours truly, Ms Mariany. I, Darren Nathaniel Khosma, will make a Thermochemistry Review for all numbers of multiple choice, and essay. Also I will give the common Ar's of elements.

2 Multiple Choice

1. 2 moles of hydrogen gas react with 1 mole of oxygen gas to form water vapor, requiring 484 kJ of heat. The thermochemical equation for this reaction is....
   A. $H_2(g) + ½\ O_2(g) \rightarrow H_2O(g)\ \Delta H = +484$ kJ
   B. $2H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)\ \Delta H = +484$ kJ
   C. $H_2O(g) \rightarrow H_2(g) + ½\ O_2(g)\ \Delta H = +484$ kJ
   D. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)\ \Delta H = -484$ kJ
   E. $2H_2O(g) \rightarrow 2H_2(g) + O_2(g)\ \Delta H = -484$ kJ

The moles in this question, are the coefficient of the reactants/products, in this case 2 moles of H_2 signifies it is $2H_2$, and the 1 mole of O_2, means that it is not needed to write what is in front of the O_2, simple stuff. Of course you have to balance the chemical reaction. And the 484 kJ of heat, since it requires the heat, it goes in the reaction, it is a endothermic reaction, hence it is +. Hence it becomes

$$2H_2 + O_2 \rightarrow 2H_2O\Delta H = +484kJ$$

The answer is B.

2. Pay attention to the thermochemical equation below.

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)\ \Delta H = -92\ kJ$

The incorrect statement about the thermochemical equation above is

A. The reaction is an exothermic reaction.
B. The decomposition reaction of NH3 is an endothermic reaction.
C. The decomposition reaction of 1 mol of NH3 requires 46 kJ of heat
D. The reaction forming 2 moles of NH3 releases 46 kJ of heat.
E. The reaction forming 2 moles of NH3 that releases 92 kJ of heat.

A, is correct, since the negative sign in the ΔH signifies release, it is a exothermic reaction. B is correct since the opposite, being decomposition, or the splitting of a compound to its elements, flipping the sign to +. C is correct because -92 : 2 is 46, and since it is decomposing, it becomes positive. E is correct because it takes 2 moles (in that reaction) to release 92 kJ of heat.
Hence D is incorrect.

3. Observe the following thermochemical equation.

$C(s) + O2(g) \rightarrow CO2(g)\ \Delta H = -394\ kJ/mol$

The heat produced from the combustion of 8.96 liters of carbon is....kJ

A. 157,6
B. 118,2
C. 88,5
D. 78,8
E. 45,7

To find the heat produced from the combustion of carbon is to find the mole of

C, to find it, assuming it is STP, divide it by 22,4

$$\frac{8,96}{22,4} = 0,4$$

To find the heat produced from the combustion of the carbon, multiply the ΔH value by the n, being the mole. Do note it's produced so it is in the - sign, don't need to write this down, since it is asked how much is being produced.

$$-394 * 0,4 = -157,6kJ$$

Hence the answer is A

4. The enthalpy change of combustion of CH_4 gas is -80 kJ/mol (Ar C= 12, H = 1). The enthalpy of combustion of 8 grams of CH_4 gas is....kJ
   A. -10
   B. -20
   C. -40
   D. -70
   E. -80

This is simple enough really, just find the n of CH_4 by dividing the mass and the Mr, then just multiply it with the entalphy change.

$$n = \frac{8}{16}$$
$$n = 0.5$$

$$n * \Delta H$$
$$0.5 * -80 = -40kJ$$

Hence the answer is C

5. 100 mL of 1M HCl solution is reacted with 100 mL of 1M NaOH solution in a calorimeter. It turns out the temperature rose from 25°C to 33°C. If the specific heat of the solution is considered the same as the specific heat of water, which is 4.18 J/g.K, then the ΔH neutralization of the above reaction is....kJ/mol (The density of the HCl and NaOH solutions is considered to be 1 gram/mL).
   A. -33,44
   B. -66,88
   C. -275,88
   D. -334,40
   E. -668,80

Finally something more challenging. In this question, we are assuming that 1 ml = 1 g. We first have to find the total mass of the reaction, being 200 g (100 ml + 100 ml), the ΔT, being the difference in temperature, is $8°C$, and the c is 4.18 J/g.K
Plugging it into this formula:

$$Q = mc\Delta T$$

We get this:

$$Q = 200 * 4.18 * 8$$

$$Q = 6688J$$

or, 6,688 kJ. And since the question uses kJ/mol, we will use the kJ
To find the ΔH, we use this formula:

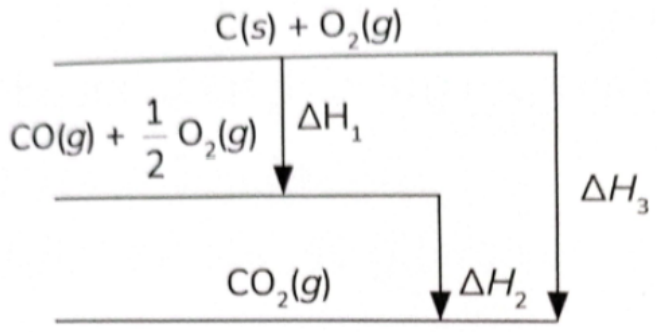
$$\Delta H = -\frac{Q}{n}$$

$$\Delta H = \frac{-6,688}{0,1}$$

$$\Delta H = -66,88kJ/mol$$

Hence the answer is B.

6. Observe the following Hess cycle.



The correct relationship between ΔH_1, ΔH_2, and ΔH_3 is....

A. $\Delta H_2 = \Delta H_1 - \Delta H_3$
B. $\Delta H_2 = \Delta H_3 + \Delta H_1$
C. $\Delta H_3 = \Delta H_1 + \Delta H_2$
D. $\Delta H_2 = \Delta H_1 + \Delta H_3$
E. $\Delta H_3 = \Delta H_2 - \Delta H_1$

Honestly, just logical, arrow of ΔH_1 + arrow of $\Delta H_2 = \Delta H_3$. If you asked, yes I somehow got this wrong, -1000 aura. **Hence the answer is C.**

7. Observe the following reaction.

C(s) + O2(g) → CO2(g) ΔH = -394 kJ/mol

2CO(g) + O2(g) → 2CO2(g) ΔH = -569 kJ/mol

The value of ΔH for the formation reaction of 140 grams of carbon monoxide (Mr = 28) is....kJ

A. -547,5
B. -219
C. -175
D. +175
E. +219

Using Hess' Law, we need to form CO and find the ΔH.

$$C(s) + O_2(g) \rightarrow CO_2(g) \Delta H = -394kJ/mol$$
$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \Delta H = -569kJ/mol | REVERSE, *0.5$$

$$C + O_2 \rightarrow CO_2 \Delta H = -394kJ/mol$$
$$CO_2 \rightarrow CO + \frac{1}{2}O_2 \Delta H = +289,5kJ/mol$$

$$C + \frac{1}{2}O_2 \rightarrow CO \Delta H = -109,5kJ/mol$$

Now find the n of CO, being:

$$n = \frac{m}{Mr}$$
$$n = \frac{140}{28}$$
$$n = 5$$

To find the total ΔH:

$$n * \Delta H$$
$$5 * -109,5 = -547,5kJ$$

Hence the answer is A.

8. The ΔH_f° values of several compounds are known.

   $\Delta H_f^\circ H_2O$ (g) = -242 kJ/mol

   $\Delta H_f^\circ CO_2$(g) = -394 kJ/mol

   $\Delta H_f^\circ C_2H_2$(g) = +52 kJ/mol

   If 52 grams of the compound C_2H_2 are completely burned, the heat produced will be....kJ

   A. -4.328
   B. -391,2
   C. -432
   D. -1.082
   E. -2.164

Now to the most infamous question of the whole WS, no. 8. Suprisingly simple as a question once done.
First find the original reaction to cause the ΔH_f°

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \Delta H_f^\circ = -242kJ/mol$$

$$C + O_2 \rightarrow CO_2 \Delta H_f^\circ = -394kJ/mol$$

$$2C + H_2 \rightarrow C_2H_2 \Delta H_f^\circ = +52kJ/mol$$

The format to form a burning/combustion reaction in this case of C_2H_2 is:

$$C_2H_2 + O_2 \rightarrow CO_2 + H_2O$$

First off remove the C from both the $2C + H_2 \rightarrow C_2H_2 \Delta H_f^\circ = +52kJ/mol$ and the $C + O_2 \rightarrow CO_2 \Delta H_f^\circ = -394kJ/mol$ by reversing it and multiplying it by 2 respectively.

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \Delta H_f^\circ = -242kJ/mol$$

$$2C + 2O_2 \rightarrow 2CO_2 \Delta H_f^\circ = -788kJ/mol$$

$$C_2H_2 \rightarrow 2C + H_2 \Delta H_f^\circ = -52kJ/mol$$

It will become like this using Hess' law, and yes it is intentional.

$$C_2H_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O$$

Now input the ΔH_f° into the reaction, do note the ΔH_f° of O_2 and H_2 are both, 0.

$$52 + 0 \rightarrow 2(-394) - 242$$

Using the law that states product - reaction, it goes:

$$-1030 - 52 = -1082$$

But, wait since the compound is completely burnt, and the mass is 52 g, we have to first find the n of the compound (DO NOTE C = 12, H = 1).

$$n = \frac{52}{26}$$
$$n = 2$$

Hence the final answer is the ΔH_c multiplied by the n

$$_c * n$$

$$-1082 * 2 = -2164kJ$$

Hence, the final answer, is E

9. Several average bond energies are known.

C = C = 146 kkal

C — H = 99 kkal

C — C = 83 kkal

C — Cl = 79 kkal

H — Cl = 103 kkal

The enthalpy change in the addition of ethylene with hydrochloric acid according to the reaction equation:

$H_2C{=}CH_2 + HCl \rightarrow CH_3{-}CH_2{-}Cl$ is....kcal

A. -510
B. -72,8
C. -12
D. +510
E. +12

For this you need to make the lewis structures, but since I'm lazy, go make it yourself.
Reactants: 4(C-C), 1(C=C), 1(H-Cl), Products: 5(C-H), 1(C-C), 1(C-Cl)

$$\Sigma Reactants - \Sigma Products$$

$$\Sigma Reactants = 4(99) + 146 + 103$$

$$\Sigma Reactants = 396 + 146 + 103$$

$$\Sigma Reactants = 645kcal$$

$$\Sigma Products = 5(99) + 83 + 79$$

$$\Sigma Products = 495 + 83 + 79$$

$$\Sigma Products = 657kcal$$

$$645 - 657 = -12kcal$$

Hence the chosen answer given by God 3000 years ago, is C.

10. The heat of decomposition is the heat required or released during the decomposition of one mole of a compound into....
    A. its elements
    B. positive or negative ions
    C. its atoms
    D. more complex compounds
    E. polyatomic molecules

Yeah, decomposition is just the release of a compound's mole into its elements, such as

$$H_2O \rightarrow H_2 + \frac{1}{2}O_2$$

Jesus Christ of Nazareth, our Lord and Saviour stated, that the answer is A.

3 Essay

Welcome to part 2 of this forsaken WS, being the essay of this forsaken WS, Gott Mitt Uns....

Figure 1: God (is) with us, used in heraldic Prussia.

1. **Use a standard enthalpies of formation table to determine the change in enthalpy for each of these reactions.**

TABLE 5.3 ▪ Standard Enthalpies of Formation, ΔH_f°, at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (kJ/mol)
Acetylene	$C_2H_2(g)$	226.7	Hydrogen chloride	$HCl(g)$	−92.30
Ammonia	$NH_3(g)$	−46.19	Hydrogen fluoride	$HF(g)$	−268.60
Benzene	$C_6H_6(l)$	49.0	Hydrogen iodide	$HI(g)$	25.9
Calcium carbonate	$CaCO_3(s)$	−1207.1	Methane	$CH_4(g)$	−74.80
Calcium oxide	$CaO(s)$	−635.5	Methanol	$CH_3OH(l)$	−238.6
Carbon dioxide	$CO_2(g)$	−393.5	Propane	$C_3H_8(g)$	−103.85
Carbon monoxide	$CO(g)$	−110.5	Silver chloride	$AgCl(s)$	−127.0
Diamond	$C(s)$	1.88	Sodium bicarbonate	$NaHCO_3(s)$	−947.7
Ethane	$C_2H_6(g)$	−84.68	Sodium carbonate	$Na_2CO_3(s)$	−1130.9
Ethanol	$C_2H_5OH(l)$	−277.7	Sodium chloride	$NaCl(s)$	−410.9
Ethylene	$C_2H_4(g)$	52.30	Sucrose	$C_{12}H_{22}O_{11}(s)$	−2221
Glucose	$C_6H_{12}O_6(s)$	−1273	Water	$H_2O(l)$	−285.8
Hydrogen bromide	$HBr(g)$	−36.23	Water vapor	$H_2O(g)$	−241.8

- **$2\ CO(g) + O_2(g) \dashrightarrow 2\ CO_2(g)$**

- **$CH_4(g) + 2\ O_2(g) \dashrightarrow CO_2(g) + 2\ H_2O(l)$**

Let us remember that the ΔH_f° of O_2 is 0, unlike Jo, me, and Hansel... (this works for H_2 too). Other than that, this is simple, it is just products - reactants.
Section Eins. DO NOTE that H_2O(l) H_2O(g) has different ΔH_f°

$$2(-110,5) + 0 \rightarrow 2(-393,5)$$

$$-221 \rightarrow -787$$

$$\Delta H_f^\circ = -556kJ$$

Section Zwei.

$$-74,8 + 0 \rightarrow -393,5 - 285,8$$

$$-74,8 \rightarrow -679,3$$

$$\Delta H_f^\circ = -604,5kJ$$

2.

Find the ΔH for the reaction below, given the following reactions and subsequent ΔH values.

$$N_2H_4\ (l) + H_2\ (g) \longrightarrow 2\ NH_3\ (g)$$

$N_2H_4\ (l) + CH_4O\ (l) \longrightarrow CH_2O\ (g) + N_2\ (g) + 3\ H_2\ (g)$	ΔH = -37 kJ
$N_2\ (g) + 3\ H_2\ (g) \longrightarrow 2\ NH_3\ (g)$	ΔH = -46 kJ
$CH_4O\ (l) \longrightarrow CH_2O\ (g) + H_2\ (g)$	ΔH = -65 kJ

I hear the angels calling me, my job is almost finished, alhamdulillah chat. Not going to yap, this is just basic Hess' law.

$$N_2H_4 + CH_4O \rightarrow CH_2O + N_2 + 3H_2 \Delta H = -37kJ$$
$$N_2 + 3H_2 \rightarrow 2NH_3 \Delta H = -46kJ$$
$$CH_4O \rightarrow CH_2O + H_2 \Delta H = -65kJ$$

Reverse $CH_4O \rightarrow CH_2O + H_2 \Delta H = -65kJ$

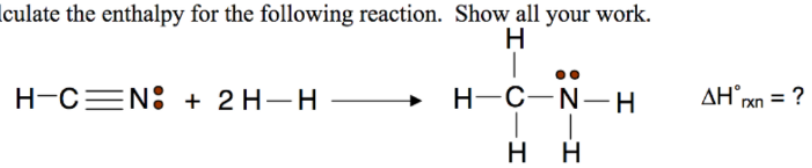
$$N_2H_4 + CH_4O \rightarrow CH_2O + N_2 + 3H_2 \Delta H = -37kJ$$
$$N_2 + 3H_2 \rightarrow 2NH_3 \Delta H = -46kJ$$
$$CH_2O + H_2 \rightarrow CH_4O \Delta H = +65kJ$$

It will end up like this

$$N_2H_4 + H_2 \rightarrow 2NH_3 \Delta H = -18kJ$$

3.

Calculate the enthalpy for the following reaction. Show all your work.



Bond	Energy in kJ/mol
C–C	347
C–N	305
C=N	615
C≡N	891
C–H	413
H–H	432
N–H	391
N–N	160
N–O	201
N=N	418

I HEAR THE ANGELS CALL MY NAME, I AM ALMOST DONE! SALVATION WILL BE NEAR, I WILL PERSEVERE! I hope I can atleast get 101 on the DT after this (about 3 hrs straight doing this)

$$\Sigma Reactants - \Sigma Product$$

$$\Sigma Reactants : 1(H-C) + 1(C \equiv N) + 2(H-H)$$

$$\Sigma Reactants : 413 + 891 + 2(432)$$

$$\Sigma Reactants : 2168kJ$$

$$\Sigma Product : 3(C-H) + 1(C-N) + 2(N-H)$$

$$\Sigma Product : 3(413) + 305 + 2(391)$$

$$\Sigma Product : 2326kJ$$

$$2168 - 2326 = -158kJ$$

4 Common Mr Values

Just incase ms doesn't give the values
C = 12
O = 16
H = 1
Cl = 35,5
Fe = 56
F = 19
Cu = 63,5
Mg = 24
N = 14