Friday Worksheet **Name: ……………….**

Heat of reaction worksheet 3

1) Pure water at 25 ^oC has a pH of 7.00 but at 100 °C has a pH of 6.14.
Knowing that pure water is neutral, indicate True or False for the following comments.
a) The self-ionisation of water, $2H_2O(l) \Rightarrow H_3O^+(aq) + OH^-(aq)$, is endothermic. True
b) It is impossible to measure the pH measurements at 100^oC. False
c) The pH measurements are affected by the low solubility of CO_2 gas at 100 ^oC. False
d) The concentration of H_3O^+ ions is not equal to the concentration of OH^- ions at 100 ^oC as it is at 25 ^oC. False
At 25 ^oC the $[H_3O^+]$ of pure water is $10^{-7.00}$, whereas the $[H_3O^+]$ at 100^oC is $10^{6.14}$ clearly a greater concentration of hydronium ions that indicates the self-ionisation of water $2H_2O(l) \Rightarrow H_3O^+(aq) + OH^-(aq)$, is an endothermic reaction.
Option D is wrong. As the question states, the pure water is neutral hence

- ⇨ $[H_3O^+]=[OH^-] = 10^{-7.00}$ at 25^oC
- ⇨ $[H_3O^+]=[OH^-] = 10^{-6.14}$ at 100^oC

2) 2.30 g of glucose (M = 180 g mol^{-1}) underwent complete combustion. The energy released was used to heat an unknown mass of water.
If the temperature of the water increased by 34.1 °C and it is assumed no heat was lost, what was the mass of the water heated?
Step 1 find the mol of glucose

$n_{(glucose)}$ = 2.30 /180.0 = 0.0128 ----1 mark

Step 2 find the energy released.

Energy = $n_{(glucose)}$ X ΔH_c(glucose)

= 0.0128 X 2816 kJ mol^-

= 36.045 kJ ----1 mark

Step 3 calculate the mass of water

Energy = 4.18 J/g/^oC X $mass_{(water)}$ X ΔT

36,045 J = 4.18 X mass X 34.1

Mass = 36.045 / (4.18 X 34.1)

Mass = 253 grams ----1 mark

3) A student used a, well insulated, vessel, containing 510.0 grams of water, to determine the molar heat of combustion of methanol. An amount of 1.004 g of liquid methanol was placed in the reaction vessel in the presence of excess oxygen and the mixture ignited by an electrical ignition heater. On this occasion, the temperature of the water increased by 9.73 °C.

a) Write a balanced chemical equation for the reaction of methanol and oxygen.

$2CH_3OH(l) + 3O_2(g) => 2CO_{2(}g) + 4H_2O(g)$

2 marks

- 1mark for correct balanced equation
- 1 mark for correct states

b) Assuming no energy was lost to the environment, use this experimental data to determine the value of ΔH for the combustion of methanol as given by the equation in a) above. Include appropriate units in your answer.

Step 1 Find the amount of methanol in mol.

1.004 / 32.0 = 0.031375 -------1 mark

Step 2 Find the amount of energy released.

Energy released = 4.18 J/g/^{o}C X mass X ΔT

= 4.18 X 510.0 X 9.73 = 20.742 kJ -------1 mark

Step 3 Find the energy released per mol of methanol

= 20.742 / 0.031375 = 661 kJ

Step 4 Find the ΔH for equation $2CH_3OH(l) + 3O_2(g) => 2CO_{2(}g) + 4H_2O(g)$

Since two mol of methanol appear in the equation the ΔH

⇨ 2 X 661 kJ = 1322 kJ -------1 mark

⇨ $2CH_3OH(l) + 3O_2(g) => 2CO_{2(}g) + 4H_2O(g)$ ΔH = -1.32 X 10^3 kJ mol^-

-------1 mark

Final answer must be expressed to the right number of significant figures and the right units.

c) The value of ΔH, calculated using the enthalpy of combustion provided in the data book, is different from the value of ΔH calculated from the experimental data provided. Provide a reason for this difference.

The molar heat of combustion in the Data book is given as 725 kJ mol^- where as the calculated molar heat of combustion of methanol is 661 kJ mol^-.

Any reason that can account of an amount of energy not absorbed by the water was acceptable. The question clearly stated that the student was to assume no loss of energy to the environment.

So any suggestion that the internal walls of the container and or other parts of the vessel absorbed heat as well as the water should be marked correct.

A common problem is not to compare the molar heat of combustion(725 kJ mol^-) from the DATA book to the calculated ΔH of the reaction (1.32 kJ mol^-), which involves two mols of methanol.