Chem 30 Thermochemistry UA Key! Oct 28^{th} 2014

1. $Q = mc\Delta t$
$= (84600g)(0.897\ J/g^{\circ}C)(660.37^{\circ}C - 25.0^{\circ}C)$
$=$ ~~4812~~ $48215814.9J$
$=$ $\underline{\underline{48.2\ MJ}}$*

*The unit conversion for Mega is on page 3 of your data booklet.

2. Note: the thermal energy released by the candle in each trial is equal.

$\therefore \quad Q_1 = Q_2$
$m_1 c\Delta t_1 = m_2 c\Delta t_2$
$(50g)(4.19\frac{J}{g^{\circ}C})(6^{\circ}C) = (150g)(4.19\frac{J}{g^{\circ}C})(t_f - 20^{\circ}C)$
$t_f = \underline{\underline{22^{\circ}C}}$

3. a.) Controlled → Mass of calorimeter ~~and water~~
Manipulated → Mass of water (although the mass does not change in this question, it is a variable <u>you</u> decide on during the real experiment)
Responding → Δt, Δm of candle.

b.) $Q = \overset{\text{water}}{mc\Delta t} + \overset{\text{calorimeter}}{mc\Delta t}$
$Q = (394g)(4.19J/g^{\circ}C)(15.5^{\circ}C) + (6g)(0.897J/g^{\circ}C)(15.5^{\circ}C)$
$= 25\ 588.33\ J + 83.421\ J$
$= 25.6718\ kJ$

$H = n\Delta_r H$
$25.6718kJ = \frac{(2.2g)}{(352.77g/mol)}\ \Delta_r H$ $\qquad \Delta_r H = \underline{\underline{-4.1 \times 10^{+3} kJ/mol}}$

4. $Na_{(s)} + \frac{1}{2} H_{2(g)} + C_{(s)} + \frac{3}{2} O_{2(g)} \rightarrow NaHCO_{3(s)} + 947.7\,kJ$

5. I → endothermic (energy is a reactant)
II → ~~exther~~ exothermic (energy is a product)
III → exothermic (energy is released when $\Delta H =$ negative ~~40.9 kJ~~)
IV → endothermic (energy is absorbed when $\Delta H =$ positive)

6. Take the ΔH and divide by coefficent infront of each species.

7. $(-877.1\,kJ) - (-74.8\,kJ) = \underline{-802.3\,kJ}$

8. 3 (benzene), 5 (ethyne) and 6 (nitrogen dioxide) all have positive ΔH values, meaning they are endothermic reactions.

9. a.) The most stable compound contains the most potential energy between their atoms and have the highest ΔH values (largest ~~value~~ absolute value). Therefore, $CH_3COOH_{(aq)}$ is most stable.

b.) The least stable compound requires the least amount of energy to decompose the compound, making the compound with the smallest ΔH value is least stable. Therefore, $C_2H_{2(g)}$ is least stable.

10.
$$NO_{(g)} \rightarrow \frac{1}{2} N_{2(g)} + \frac{1}{2} O_{2(g)} \qquad \Delta H = -90.2\,kJ$$
$$\frac{1}{2} N_{2(g)} + O_{2(g)} \rightarrow NO_{2(g)} \qquad \Delta H = +33.2\,kJ$$
$$NO_{(g)} + \frac{1}{2} O_{2(g)} \rightarrow NO_{2(g)} \qquad \Delta H = -57.0\,kJ$$

11. $CuO_{(s)} + CO_{(g)} \rightarrow Cu_{(s)} + CO_{2(g)}$

$-157.3\ kJ/mol \quad -110.5\ kJ/mol \quad 0\ kJ/mol \quad -393.5\ kJ/mol$

$$\Delta_r H = \sum_{products} n\Delta H - \sum_{reactants} n\Delta H = \left[1(-393.5 kJ/mol)\right] - \left[1(-157.3 \tfrac{kJ}{mol}) + 1(-110.5 \tfrac{kJ}{mol})\right]$$

$$\Delta_r H = -125.7\ kJ/mol$$

12. $\Delta_r H = \left[1(-285.8 kJ/mol) + 1(-393.5 kJ/mol)\right] - \left[-108.6 kJ/mol\right]$

$= -570.7\ kJ/mol$

13. $\cancel{\Delta_r H = [3(-277.6 kJ/mol)) + 3(-285.8 kJ/mol))}$

$\Delta_r H = \left[3(-277.6 kJ/mol)\right] - \left[3(-285.8 kJ/mol) + 1(-1273.3 kJ/mol)\right]$

$= -832.8\ kJ/mol - (-2130.7 kJ/mol)$

$= 1297.9\ kJ/mol$

14. $3\left[O_{2(g)} \rightarrow 2\,O_{(g)} \quad \Delta H = +498.\ kJ\right]$

$\left[2\,O_{3(g)} \rightarrow 3\,O_{2(g)} \quad \Delta H = 284\ kJ\right]$

$\cancel{3 O_{2(g)}} + 2O_{3(g)} \rightarrow 6\,O_{(g)} + \cancel{3 O_{2(g)}} \quad \Delta H = \cancel{782}\ 1210\ kJ/mol.$

$\downarrow \div 2 \quad \downarrow \div 2 \quad \downarrow \div 2$

$O_{3(g)} \rightarrow 3\,O_{(g)} \quad \Delta H = 605\ \frac{kJ}{mol}$

15. a.) The difference between the Potential energy of the reactants and products is the ΔH. of reaction.

b.) The energy that needs to be put into the reaction, measured from the reactants to "the top of the hill" is the activation energy.

c.) The energy that needs to be put into the reaction, read from right to left, from products to the "top of the catalyzed hill" is reverse activation energy.

15. 1.) None.
2.) Kinetic energy change $(Q = mc\Delta t)$
3.) Potential energy change, catalysed, chemical bonds formed
4.) Kinetic energy change.
5.) Potential energy change, chemical bonds formed.
6.) Kinetic energy change.
7.) Potential energy change.
8.) Kinetic energy change.