Enthalpy: Pre-Lab

a) (i) $2HCl_{(aq)} + Mg_{(s)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

(ii) $2HCl_{(aq)} + MgCO_{3(s)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

(iii) $H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(g)}$

(iv) $C_{(s,graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$

(v) $Mg_{(s)} + C_{(s,graphite)} + \frac{3}{2} O_{2(g)} \rightarrow MgCO_{3(s)}$

b)

$$\begin{array}{l} Rxn(i) \\ -Rxn(ii) \\ +Rxn(iii) \\ +Rxn(iv) \\ \hline Rxn(v) \Rightarrow \text{overall rxn} \end{array} \quad \Rightarrow \quad \begin{array}{l} \Delta H_{rxn,i} \\ -\Delta H_{rxn,ii} \\ +\Delta H_{rxn,iii} \\ +\Delta H_{rxn,iv} \\ \hline \Delta H_{rxn,v} \Rightarrow \text{heat of formation of } MgCO_3 \end{array}$$

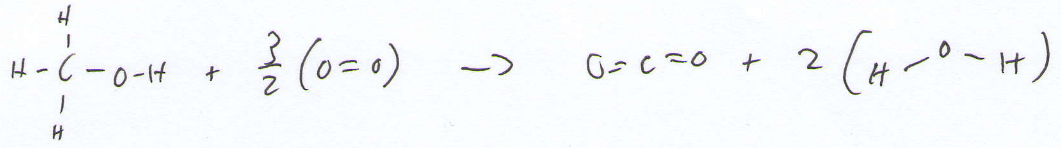
c) Hess's Law

d) $CH_3OH_{(l)} + \frac{3}{2} O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$

e) $\Delta H_c^\circ(CH_3OH) = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$

$= [\Delta H_f^\circ(CO_2) + 2\Delta H_f^\circ(H_2O)] - [\Delta H_f^\circ(CH_3OH) + \frac{3}{2}\Delta H_f^\circ(O_2)]$

$\Delta H_c^\circ(CH_3OH) = [3\Delta H(C-H) + \Delta H(C-O) + \Delta H(O-H) + \frac{3}{2}\Delta H(O=O)] - [2\Delta H(C=O) + 4\Delta H(O-H)]$



$$H_3C\text{-}O\text{-}H + \frac{3}{2}(O=O) \rightarrow O=C=O + 2(H-O-H)$$

f) $q_{\text{released by methanol combustion}} = -q_{\text{absorbed by } H_2O} = -ms\Delta T = -(200\,g)(4.184\,\frac{J}{g\,^\circ C})(40\,^\circ C)$

$q_{rxn} = -33472\,J$

$\Delta H_c^\circ(CH_3OH) = \frac{-33472\,J}{1.5\,g\ \text{methanol}} \times \frac{32.04\,g\ \text{methanol}}{1\ \text{mol methanol}} = -714.96\,kJ/mol$

$\Delta H_c^\circ(CH_3OH) = \Delta H_f^\circ(CO_{2(g)}) + 2\Delta H_f^\circ(H_2O_l) - \Delta H_f^\circ(CH_3OH_l) + \frac{3}{2}\Delta H_f^\circ(O_{2g})$

$-714.96\,kJ/mol = -393.5\,kJ/mol + 2(-285.8\,kJ/mol) - \Delta H_f^\circ(CH_3OH_l) + \frac{3}{2}(0)$

$\Delta H_f^\circ(CH_3OH_l) =$ ~~[illegible]~~ -249.74 kJ/mol

↳ need $\Delta H_f^\circ(H_2O_l)$, but I gave you $\Delta H_f^\circ(H_2O_g)$, so your # will be a little different

* This is as far as you could get with the information I gave. The rest of the problem is solved on the next page, though you were not graded on it. *

To calculate bond enthalpies from formation reactions, all reactants and products must be in the gas phase. So, starting with the formation reaction of liquid methanol

$$C_{(s,\,graphite)} + \frac{1}{2}O_{2(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(l)} \qquad \Delta H_f^\circ(CH_3OH_l) = \overset{-249.74}{\cancel{[illegible]}}\ \frac{kJ}{mol}$$

We see that we need to sublime the carbon and evaporate the methanol:

$$C_{(s,\,graphite)} + \frac{1}{2}O_{2(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(l)} \qquad \Delta H_f = \overset{-249.74}{\cancel{[illegible]}}\ kJ/mol$$

$$CH_3OH_{(l)} \rightarrow CH_3OH_{(g)} \qquad \Delta H_{vap} = 35.278\ kJ/mol$$

$$C_{(g)} \rightarrow C_{(s,\,graphite)} \qquad \Delta H_{dep} = -715.0\ kJ/mol$$

$$C_{(g)} + \frac{1}{2}O_{2(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(g)} \qquad \Delta H_{rxn} = \underset{-929.46}{\cancel{[illegible]}}\ kJ/mol$$

Now that all products and reactants are in the gas phase, we can calculate bond enthalpies:

$$\Delta H_{rxn} = 2\Delta H(H-H) + \frac{1}{2}\Delta H(O=O) - 3\Delta H(C-H) - \Delta H(C-O) - \Delta H(O-H)$$

$$-929.46\ \frac{kJ}{mol} = 2\left(436\ \frac{kJ}{mol}\right) + \frac{1}{2}\left(498\ \frac{kJ}{mol}\right) - 3\left(413\ \frac{kJ}{mol}\right) - \left(360\ \frac{kJ}{mol}\right) - \Delta H(O-H)$$

$$\Delta H(O-H) = 415.46\ \frac{kJ}{mol}$$

g) $$\frac{1.5\ g\ CH_3OH}{20\ min} \times \frac{1\ mol\ CH_3OH}{32.04\ g\ CH_3OH} \times \frac{1\ min}{60\ s} = 3.9 \times 10^{-5}\ mol/s$$