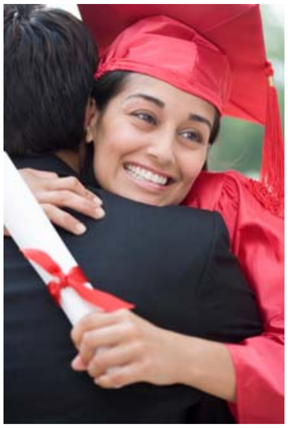


Homework Review

Special Problem 9a
(Heat of Reaction at Different T's)

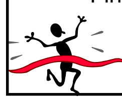
See Excel Sheet

Business

- Winter and Spring TA positions available (apply online through ChE web page)
  - "Department" Menu → TA Application
- Answers to next two problems are now in the homework hints! (9.23 and 9.32)

Last but not least…

- Counting today
  - 5 more class periods, including
    - 3 classes on Energy balances
    - 1 class on transient balances
    - Review for Exam 3… then Exam 3
  - Case Study (Ch. 14 problems)
  - Review for Final Exam
  - Final Exam



The End is Near!!

Goals Today

1. Energy Balance with ΔH_r^0 (single rxn)
2. Energy Balance with ΔH_f^0 (multiple rxns)

1. Energy Balance with only One Reaction

Board Problem
$A \rightarrow bB$

Path method, incomplete conversion

Caution on Enthalpy Tables

Find $\hat{H}_{H2O,liq}$ at 25°C, 1 atm

1. Use steam tables (Table B.5)
   (104.8 kJ/kg)(kg/1000 g)(18g/mol) = 1.886 kJ/mol
   sat'd liquid (0.0317 bar)
2. Use ΔH_f^0
   Table B.1 says ΔH_f^0 = -285.84 kJ/mol at 25°C and 1 atm

What about VdP term since reference for steam tables is at 0.0317 bar?

V∆P = (0.00101 m³/kg)[1 atm - .0317 bar(atm/1.01325bar)](1.01325e5 N/m²/atm)
= (99.1 N-m/kg)(kg/1000 g)(18 g/mol)(J/N-m)(kJ/1000J)
= 1.78e-3 kJ/mol (not enough to make a difference)

Bottom line: Do not mix and match enthalpies from different tables!

Look at Table B.7

- How does $\hat{H}_{liq\ water}$ change with pressure at 50°C? (use steam tables)
  - 0.5 bar → 209.3 kJ/kg
  - 1.0 bar → 209.3 kJ/kg
  - 5.0 bar → 209.7 kJ/kg (0.19% above 0.5 bar value)
- Pretty small change!! (for a liquid)
  - But relatively small change in pressure
- What about for steam?
  - At 350°C, $\Delta\hat{H}_{5bar}$ vs $\Delta\hat{H}_{0.5bar}$ = 0.28% decrease

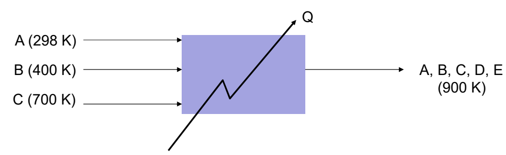
1. Energy Balance with Multiple Reactions using ΔH_f^o

- Most common approach
- Most reliable approach

$$\Delta H + \Delta E_k + \Delta E_p = Q - W_s$$

$$\Delta \dot{H} + \Delta \dot{E}_k + \Delta \dot{E}_p = \dot{Q} - \dot{W}_s$$

- $\Delta\dot{H} = \dot{H}_{\text{out}} - \dot{H}_{\text{in}} = (\sum n_i \hat{H}_i)_{out} - (\sum n_i \hat{H}_i)_{in}$
- $\hat{H}_i = \Delta\hat{H}_{i,f}{}^{o} + \int_{T_{ref}}^{T} \hat{C}_p dT$



Idea: Construct a Table

In

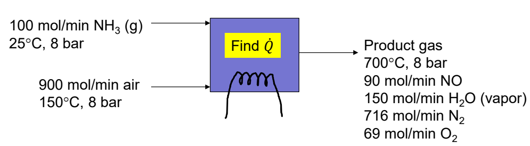
Species	n_i	T	$\hat{H}_i$	$n_i\hat{H}_i$
A	2	298	?	?
B	1	400	?	?
C	.5	700	?	?
D	0	-		
E	0	-		

Out

Species	n_i	T	$\hat{H}_i$	$n_i\hat{H}_i$
A	.5	900	?	?
B	.1	900	?	?
C	.05	900	?	?
D	1	900	?	?
E	1.3	900	?	?

Example: Problem 9.20

$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$
$2\ NH_3 + 3/2\ O_2 \rightarrow N_2 + 3\ H_2O$



Step 1: Write the mole balance (already done)

Step 2: Write the energy balance

Energy Balance with ΔH_f^o

$$\Delta \dot{H} + \cancel{\Delta \dot{E}_k} + \cancel{\Delta \dot{E}_p} = \dot{Q} - \cancel{\dot{W}_s}$$

- $\Delta\dot{H} = \dot{H}_{\text{out}} - \dot{H}_{\text{in}} = (\sum n_i \hat{H}_i)_{out} - (\sum n_i \hat{H}_i)_{in}$
- $\hat{H}_i = \Delta\hat{H}_{i,f}{}^{o} + \int_{T_{ref}}^{T} \hat{C}_p dT$

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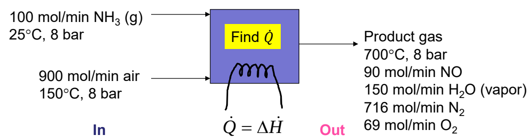

In

Species	$\dot{n}_i$	T	$\hat{H}_i$	$\dot{n}_i\hat{H}_i$
NH_3	100	25	?	?
O_2	189	150	?	?
N_2	711	150	?	?
NO	0	-		
H_2O (g)	0	-		

Out

Species	$\dot{n}_i$	T	$\hat{H}_i$	$\dot{n}_i\hat{H}_i$
NH_3	0	-	-	-
O_2	69	700	?	?
N_2	716	700	?	?
NO	90	700	?	?
H_2O (g)	150	700	?	?

Excel Sheet