UNIVERSITY CEU SAN PABLO
SCHOOL OF PHARMACY
DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY

COMPLEMENTARY PROBLEMS OF PHYSICAL CHEMISTRY

2018-19

LESSON 1

1. Calculate ΔU when 1 mole of argon is heated from 25 ºC to 125 ºC and its volume changes from 5 dm^3 to 6.35 dm^3. Consider ideal gas behaviour

Data: $R = 0.082\ l \cdot atm \cdot K^{-1} \cdot mol^{-1} = 1.987\ cal \cdot K^{-1} \cdot mol^{-1} = 8.314\ J \cdot K^{-1} \cdot mol^{-1}$

$\overline{C}_V = 12{,}472\ J \cdot K^{-1} \cdot mol^{-1}$

Solution: $\Delta U = 1247.20\ J$

2. One mole of a monoatomic ideal gas undergoes the next cycle comprising steps A, B and C and involving the states 1, 2 and 3. Fill a table with:

a) P, V and T for each state.

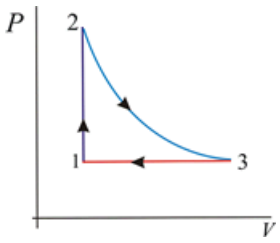
b) W, Q, ΔU and ΔH for each step and for the cycle.

Data: $R = 0.082\ l \cdot atm \cdot K^{-1} \cdot mol^{-1} = 1.987\ cal \cdot K^{-1} \cdot mol^{-1} = 8.314\ J \cdot K^{-1} \cdot mol^{-1}$

$V_1 = 22.4\ l \cdot mol^{-1}$, $T_1 = 273\ K$

$V_2 = 22.4\ l \cdot mol^{-1}$, $T_2 = 546\ K$

$V_3 = 44.8\ l \cdot mol^{-1}$, $T_3 = 546\ K$



Solution: a)

State	P / (atm)	V (l/mol^{-1})	T / (K)
1	0.9993	22.4	273
2	1.9987	22.4	546
3	0.9993	44.8	546

b)

Step	Type	W / (cal)	q / (cal)	ΔU / (cal)	ΔH / (cal)
A	Isochoric	0	813.68	813.68	1356.13
B	Isothermal	-751.99	751.99	0	0
C	Isobaric	542.79	-1,356.12	-813.68	-1,356.13
Cycle		-209.20	209.20	0	0

3. Two moles of an ideal gas 25 º C undergo a reversible isothermal expansion from an initial volume of 3 to a final one of 10 l. Determine Q, W, ΔU, ΔH and ΔS.

Data: $R = 0.082\ l \cdot atm \cdot K^{-1} \cdot mol^{-1} = 1.987\ cal \cdot K^{-1} \cdot mol^{-1} = 8.314\ J \cdot K^{-1} \cdot mol^{-1}$
$\overline{C}_P = 5R / 2$

Solution: Q = 1424.65 cal w = -1424.65 cal; ΔU = 0, ΔH = 0, ΔS = 4.780 cal · K^{-1}

4. Calculate ΔU, ΔH and ΔS when one mole of liquid water at 25 ° C and 1 atm is transformed in one mole of steam at 100 ° C and 1 atm.

Data: $R = 0.082\ l \cdot atm \cdot K^{-1} \cdot mol^{-1} = 1.987\ cal \cdot K^{-1} \cdot mol^{-1} = 8.314\ J \cdot K^{-1} \cdot mol^{-1}$
$\overline{\Delta H}_V$ (H_2O, 373 K) = 40.79 kJ ·mol^{-1}; $\overline{C}_p$ (H2O) = 75.30 J · K^{-1} ·mol^{-1};
ρ ($H_2O_{(l)}$, 298 K) = 0.9998 g · cm^{-3}; ρ ($H_2O_{(l)}$, 373 K) = 0.958 g cm^{-3};
ρ ($H_2O_{(v)}$, 373 K) = 5.98 · 10^{-4} g · cm^{-3}

Consider that the molar heat capacity is independent of temperature

Solution: ΔU = 43387.4 J.; ΔH = 46437.5 J; ΔS = 126.26 J · K^{-1}

5. Calculate for the isobaric transformation of 10 kg of water at 20 º C and 1 atm to steam at 250 º C:

a) ΔS of the system.
b) Indicate if these data are enough to know the spontaneity of the process.
c) What are the differences if the transformation takes place at 100 º C and 1 atm? Why?

Data: Cp (H_2O, l) = 4,189 J · kg^{-1} · K^{-1};
Cp (H_2O, v) = 1.670 +0.49 T +1.86 · $10^6 T^{-2}$ (J · kg^{-1} · K^{-1})
ΔHv = 730.8 J · kg^{-1}

Solution: ΔSsist = 803.19 J K-1; **b)** they are not, ΔG is needed; **c)** just reversible vaporization would occur.