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FIRST SEMESTER 2022-2023 | **MID SEMESTER TEST (CLOSED BOOK)**
PHYSICAL CHEMISTRY I (CHEM F211) | **DURATION: 90 MINUTES**
MARKS :70 | **02/11/2022**

Answer all questions. All parts of the question should be answered together in the Answer template provided.

Useful data: R = 8.314J/(mol-K)= 1.987 cal/(mol-K)= 82.06 cm^3atm/(mol-K); Molar masses of He, H, O, C, N = 4.00, 1.0, 16.0, 12.0,14.0 g mol^{-1} respectively ; 1 bar = 0.9869 atm= 750 torr; Avogadro's constant = 6.022 x 10^{23} mol^{-1}

Q.1(a) A certain perfect gas with $C_{V,m}$ = 2.5 R, at all temperatures, undergoes a reversible isobaric expansion from 1.00 atm, 20 dm^3 to 1.00 atm, 40 dm^3. Calculate w, q, ΔU and ΔH for 2 moles. All energy units should be reported in kJ. **[8]**

w	**q**	**ΔU**	**ΔH**

Q.1(b) Calculate the change in entropy when 2.50 moles of a perfect monatomic gas undergoes the following change from (1.50 atm , 400 K) → (3.00 atm, 600 K) with $C_{V,m}$ = 1.5 R for all temperatures . **[5]**

Q.2(a) The standard enthalpy of formation at 25°C of liquid methyl acetate, CH_3COOCH_3, is **-** 442 kJ/mol. Find the $\mathbf{\Delta_c H°_{298}}$ and $\mathbf{\Delta_f U°_{298}}$ of CH_3COOCH_3 (*l*). Given the standard heats of formation of CO_2(g) and H_2O(*l*) are – 393.51 and -285.83 kJ mol^{-1} respectively. [**8**].

$\Delta_c H°_{298}$(kJ/mol)	$\Delta_f U°_{298}$(kJ/mol)

Q.2(b) For solid 1,2,3-trimethylbenzene, $C°_{P,m}$ = 0.62 J mol^{-1} K^{-1} at 10.0 K. Find $S°_m$ at 10.0 K for this substance. Find $S°_m$ at 6.0 K for this substance. [**6**]

$S°_m$ at 10.0 K(J/mol-K)	$S°_m$ at 6.0 K(J/mol-K)

Q.3(a) At 100 ºC, the vapour pressures of hexane and octane are 1836 and 354 torr respectively. A certain liquid mixture of these two compounds has a vapour pressure of 666 torr at 100 ºC. Find the mole fraction in the liquid mixture and in the vapour phase. Assume an ideal solution. Report all answers in three places of decimal. [**8**]

$x_{hex,l}$	$x_{oct,l}$	$x_{hex,v}$	$x_{oct,v}$

Q.3(b) Using the slope method**,** the tangent drawn to the curve at n_{MgSO4} = 0.05 mol is found to have a slope of -0.54 cm^3/mol. If the volume of the solution is 1001.697 cm^3/mol, find the partial molar volumes of $MgSO_4$ and H_2O(cm^3/mol) for a 0.05 mol/kg $MgSO_4$ (*aq*) solution. **[4]**

$\bar{V}_{MgSO_4}$	$\bar{V}_{H_2O}$

Q.4(a) Find **ΔA** and **ΔG** (in J) when 0.200 mol of He(g) is mixed at constant T and P with 0.300 mol of O_2(g) at 27°C. Assume ideal gases. **[5]**

ΔA	ΔG

Q.4(b) For a liquid with a typical values $\alpha = 10^{-3}\ K^{-1}$, $\kappa = 10^{-4}\ atm^{-1}$, $V_m = 50\ cm^3/mol$, $C_{P,m} =$ 40 cal/mol-K, calculate at 25°C and 1 atm **(a)** $(\partial H_m/\partial P)_T$.**(b)** $(\partial U/\partial V)_T$ .Report all answers with proper units (with energy units in Joules). [**3 + 3 = 6**]

$(\partial H_m/\partial P)_T$	$(\partial U/\partial V)_T$

Q.5 At 35°C, the vapor pressure of chloroform is 295.1 torr, and that of ethanol (eth) is 102.8 torr. A chloroform–ethanol solution at 35°C with $x^l_{eth} = 0.200$ has a vapor pressure of 304.2 torr and a vapor composition of $x^v_{eth} = 0.138$. [**8(2x4) + 3**]

(***a***) Calculate γ_I and a_I for chloroform and for ethanol in this solution.

(***b***) Calculate ΔG for the mixing of 0.20 mol of liquid ethanol and 0.80 mol of liquid chloroform at 35°.

γ_I**(eth)**	γ_I**(chl)**	a_I**(eth)**	a_I**(chl)**	ΔG

Q.6 Choose the Correct alternative/s [**3 x 3 = 9**]

(i) In the reaction, $2NH_3 \rightarrow N_2 + 3H_2$, suppose initially 0.80 mol of NH_3, 0.70 mol of H_2 and 0.40 mol of N_2 are present. After some time ***t***, 0.55 mol of H_2 are present. What is ξ and the number of moles of NH_3 and N_2 present at time ***t*** respectively.

(a) 0.05, 0.90, 0.40 **(b)** 0.10,0.85, 0.45 **(c)** -0.05, 0.90,0.35 **(d)** 0.20, 1.00, 0.50

(ii) A heat engine absorbs 750 KJ of heat from the source at 400 K and rejects 500 kJ of heat to the sink at 300 K. This represents a/an …………… cycle.

(a) Reversible **(b)** Impossible **(c)** Irreversible **(d)** Data insufficient

(iii) For the electrolyte Calcium Phosphate, $\nu_\pm$ is

(a) 81 **(b)** 1.73 **(c)** 2.55 **(d)** 108

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