Birla Institute of Technology & Science, Pilani, Rajasthan 333031
First Semester 2015-2016
Course Number: CHEM F111 Course Title: General Chemistry Marks: 10
Tutorial Problem Set 3 (based on Lecture No.'s: 17-21 in the course hand out)
Instructions to the student: *The following problems should be solved as home assignment within a week of display. One or more problems will be assigned as a closed book class test in the following tutorial hour.*

Q1. (a) What can be the value of δ for a nucleus in a spectrometer operating at 200 MHz, if it has a resonance frequency of 300 MHz.
(b) For the HNMR spectrum of the following compounds, predict: (i) the no. of signals and (ii) the position of the signals relative to each other:
(i) Ethyl chloride, (ii) Isopropyl chloride, (iii) 1-chloropropane. [4 + 2 × 3]

Q2. (a) State the total no. of signals that will be observed in the ^{13}C NMR spectrum of the following compounds. Also label the different carbons that would give rise to those signals.
(i) Methylcyclopentane, (ii)2-Methylbut-2-ene [5]
(b) What magnetic field strength is required for proton magnetic resonance at 220 MHz. Given g factor for proton is 5.585 and the nuclear magneton (μ_n) is 5.047×10^{-27} J Tesla^{-1}. [5]

Q3. (a)The HNMR spectrum of a compound C_3H_5ON shows the following absorptions: δ 2.1 (brs, 1H); δ 2.5 (triplet, 2H); δ 3.9 (triplet, 2H). Predict the structure and state which peak is due to which set of protons. [5]
(b) Given the following compound: $CH_3CH_2COOCH_2Br$. Answer the following questions pertaining to its ^{1}HNMR spectrum: (a) How many signals will be observed in its ^{1}HNMR spectrum? (b) What will be the multiplicity of each signal? (c) Which set of protons will appear most downfield? [5]

Q4. (a) A chemical reaction takes place in a container of cross-sectional area 50.0 cm^2. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121 kPa. Calculate the work done by the system. [4]
(b) One mol of an ideal gas in an isolated system expands freely from 28.0 L at 400 K to 42.0 L at 400 K. Calculate ΔS_{system}, $\Delta S_{surroundings}$ and $\Delta S_{universe}$. Show that the results are in accordance with the second law of thermodynamics. (Hint: Free expansion of a gas is an irreversible process). R = 8.314 J K^{-1} mol^{-1}. [6]

Q5. A sample consisting of 2.00 mol of He (assumed to behave ideally) is expanded isothermally at 22°C from 22.8 dm^3 to 31.7 dm^3, (a) reversibly, (b) against a constant external pressure equal to the final pressure of the gas, and (c) freely (against zero external pressure). For the three processes calculate q, w, Δu, and ΔH. [10]

Q6. (a) A piece of Zinc of mass 5.0 gm is placed in a beaker of dilute hydrochloric acid. Calculate the work done by the system as a result of the reaction. The atmospheric pressure is 1.1 atm and temperature is 23°C. [8]
(b) Given that the standard enthalpy of combustion of graphite is -393.51 kJ mol^{-1} and that of diamond is -395.41 kJ mol^{-1}, calculate the enthalpy of the graphite-to-diamond transition [2]

Q7. (a) Calculate ΔH and ΔG when 2 mol of an ideal gas expands isothermally and reversibly from 30.0 L to 45.0 L at 300 K. R = 8.314 J K^{-1} mol^{-1}. [5]
(b) How much glucose does a person of mass 60 kg need to consume to climb through 10 m? Given that, the change in Gibbs energy that accompanies the oxidation of 1.0 mol of $C_6H_{12}O_6(s)$ to carbon dioxide and water vapour at 25 ^{o}C is -2828 kJ. g = 9.81 ms^{-2}, $M_{C_6H_{12}O_6}$ = 180 g mol^{-1}. [5]

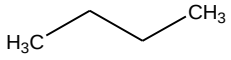
Q8. (a) Calculate Δ_rS^o for the reaction, $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ at 25^{o}C. Given that, $S_m^o(H_2, g)$ = 131 J K^{-1} mol^{-1}, $S_m^o(O_2, g)$ = 205 J K^{-1} mol^{-1}, and $S_m^o(H_2O, l)$ = 70 J K^{-1} mol^{-1}. For this reaction, Δ_rH^o = - 572 kJ mol^{-1}.

Calculate $\Delta S_{surroundings}$. Show that the results obtained are in accordance with the second law of thermodynamics. [6]

(b) . Calculate ΔH and ΔG for the melting of 1 mol of ice at 0^oC and 1 atm. Given that, latent heat of fusion of ice at 0^oC and 1 atm is 333 Jg^{-1}. How does the result obtained make sense? [4]

Q9. (a) A compound having molecular formula $C_8H_{10}O_2$ shows the following spectral data:
1HNMR: δ 7.0 (doublet, 2H); δ 6.8 (doublet, 2H); δ 4.8 (broad singlet, 1H); δ 3.9 (quartet, 2H); δ 1.4 (triplet, 3H). IR (important peaks): 3300 cm^{-1} (broad); 1100 cm^{-1} (strong). Predict the structure of the compound and state which NMR peak is due to which set of protons. [6]

(b) How many ^{1}HNMR signals would you expect from each of the following compounds? Label each set of protons clearly by drawing structures [4]

(i) 

(ii)