INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
CHEMISTRY DEPARTMENT

Date of Examination: 23. 11. 2011 **Time:** 3 Hrs. **Full Marks:** 50

No. of Students: 32 **Semester:** Autumn 2011-12 **Department:** Chemistry

Course: PREP CHEMISTRY **Subject No.** CY00001 **Subject Name:** Chemistry

PART- A: PHYSICAL CHEMISTRY

(Answer all Questions) **Marks =25**

Attention: Physical Chemistry & Inorganic Chemistry SHOULD BE ANSWERED in SEPARATE Answer Scripts

[$k = 1.38 \times 10^{-23}$ J K^{-1}; $R = 8.314$ J K^{-1} mol^{-1}; 1 bar = 1×10^5 Pa; g= 9.81 ms^{-2}; 1F = 96500 C/mol]

Q1. State whether the following statements are True or False: **.... (1 × 6 = 6)**

(i) When a system changes from one state to another along an adiabatic path, the amount of work done will depend on the path through which the transformation is carried out.

(ii) For reversible expansion of an ideal gas through a given volume change from the same initial state, the work done $(-w_{isothermal}) > (-w_{adiabatic})$

(iii) Adiabatic processes are isentropic.

(iv) The C_V for all monoatomic gases behaving ideally has value equal to $(^3/_2)R$

(v) In a vaporization process, the ΔH for the process is positive while the ΔS is negative.

(vi) For a spontaneous process at constant temperature and pressure, $(\Delta G)_{T,P}$ is be negative (≤ 0) and for a spontaneous process at constant temperature and volume, $(\Delta A)_{T,V}$ should be negative.

Q2. Fill in the blanks with appropriate expressions/ words: **.... (1 × 4 = 4)**

(i) $\left[\left(\frac{\partial T}{\partial P}\right)_H\right]$ is known as the expression for _____

(ii) $\left[-\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T\right]$ is known as the _____

(iii) $dS \geq \left(\frac{\partial q_{irrev}}{T}\right)$ is known as the_____

(iv) $\left[1-\left(\frac{Q_C}{Q_H}\right)\right]$ is the expression for _____ for a heat engine.

Q3. Shade the area in a P-V diagram to represent the work done when an ideal gas expands: **.... (2 × 2 = 4)**

(a) Isothermally reversibly from an initial volume of V_1 at pressure P_1 to final volume of V_2 at pressure P_2; and
(b) Isothermally irreversibly from an initial volume of V_1 at pressure P_1 to final volume of V_2 at pressure P_2

Q4. Draw the P-V curve of an ideal gas to compare its expansion from the same initial state through the following two processes: **.... (½ × 2 = 1)**

(a) Isothermal reversible process from an initial volume of V_1 at pressure P_1 to final volume of V_2 at pressure P_2;
(b) Adiabatic reversible process from an initial volume of V_1 at pressure P_1 to final volume of V_2 at pressure P_2.

Q5. From the given reaction data: $A + B \rightarrow C + D$ .... $\Delta H° = -10$ kcal **.... (1 × 2 = 2)**

and, $C + D \rightarrow E$ .... $\Delta H° = 15$ kcal

Calculate the $\Delta H°$ for the following reactions: (a) $2C + 2D \rightarrow 2A + 2B$; (b) $A + B \rightarrow E$

Q6. What will be the heat required **(in kcal)** to convert 40 g of ice at –10 °C to steam at 120 °C. Assume the pressure is constant for the process at 1 atm. [Given: specific heat capacity of ice, steam and water are 0.5, 0.5 and 1.0 cal/g K respectively. ΔH_{fus} of ice at 0 °C = 80 cal/g and ΔH_{vap} for water at 100 °C = 540 cal/g]. **.... (1 × 3 = 3)**

Q7. A system containing 1 mole of gas is initially at state A, at pressure of 2P and volume V. The gas in the system is allowed to undergo two processes to reach state C. In the first process, the gas is first allowed to undergo an isobaric reversible heating step during which system changes to state B, and the volume of the gas increases to 2V. Following this, the gas is subjected to isochoric reversible cooling step during which system changes to state C, when the pressure of the gas falls to P. In the second process, the gas is first allowed to undergo an isochoric reversible cooling step during which system changes to state D, where the pressure of the gas falls to P. Following this, the gas is subjected to an isobaric reversible heating step during which system changes to state C, and the volume of the gas increases to 2V.

(i) Draw the p-V diagram for the two processes.
(ii) What will be the work done when the system changes from initial state A to state C through the first process?
(iii) What will be the work done when the system changes from initial state A to state C through the second process?
(iv) What will be the net work, ΔU, ΔH and the q for the process if the system goes from state A→B→C→D→A? Will heat be absorbed or dissipated by the system in this process? **.... (1 × 3 = 3)**

Q8. Calculate ΔG and ΔS for the evaporation of water at 100 °C. Given: ΔH_{vap} = 40.7 kJ/mol. Is the entropy for water greater than water vapour? **.... (1 × 2 = 2)**

PART- B: INORGANIC CHEMISTRY

(Answer all Questions) **Marks =25**

(Use a separate Answer script for Part-B)

Q1. Write the electronic configurations of following atomic numbers: **.... (1 × 5 = 5)**

i). 20; ii). 23; iii). 27; iv). 30; v). 35

Q2. Write the Energy level diagram and Calculate the bond order forof following species: **.... (2 × 5 = 10)**

i). HHe^+; ii). B_2 iii). C_2^{2-}; iv). O_2^{2-}; v). NO^+

Q3. Calculate the no of unpaired electrons of the following complexes: **.... (1 × 5 = 5)**

i) $[Co(CN)_6]^{3-}$; ii) $[Fe(CN)_6]^{4-}$; iii) $[Co(Cl)_4]^{2-}$ iv) $[Zn(H_2O)_4]^{2+}$ v) $[Cu(H_2O)_4]^{2+}$

Signature of the Paper Setters:
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