

QB365  
Important Questions - Thermodynamics  
11th Standard CBSE

**Chemistry**

Reg.No. : 

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Time : 01:00:00 Hrs

Total Marks : 50

**Section-A**

- 1) Heat capacity (Cp) is an extensive property but specific heat (C) is an intensive property. What will be the relation between Cp and C for 1mole of water? 1
- 2) Identify the state functions and path functions out of the following. Enthalpy, entropy, heat, temperature, work, free energy. 1
- 3) Predict the change in internal energy for an isolated system at constant volume. 1
- 4) What an ideal gas expands into vacuum, there is neither adsorption nor evolution of heat. Why? 1
- 5) How can you say that universe is going towards chaos? 1
- 6) Why in some reactions heat is evolved while some reactions take place only on absorption of heat? 1
- 7) The molar enthalpy of vaporisation of acetone is less than that of water. Why? 1
- 8) One mole of acetone requires less heat to vaporise than 1 mole of water. Which of the two liquids has higher enthalpy of vaporisation? 1
- 9) If enthalpy of fusion and enthalpy of vaporisation of sodium metals are 2.6 and 98.2KJ mol<sup>-1</sup> respectively, what is the enthalpy of sublimation of sodium. 1
- 10) At 1 atm will the  $\Delta_f H^\circ$  be zero for Cl<sub>2</sub>(g) and Br<sub>2</sub>(g)? Explain. 1

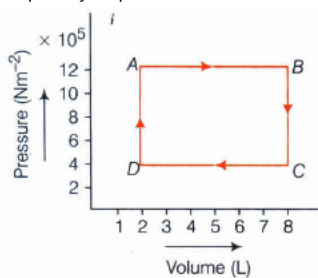
**Section-B**

- 11) Comment on the thermodynamic stability of NO(g), given 2  
 $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g); \Delta_f H^\circ = 90kJmol^{-1}$   
 $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g); \Delta_f H^\circ = 90kJmol^{-1}$   
 $\frac{1}{2}O_2(g) \rightarrow NO_2(g); \Delta_f H^\circ = -74kJmol^{-1}$
- 12) The enthalpy of reaction for the reaction 2  
 $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$  is  $\Delta_r H^\circ = -572 \text{ KJ mol}^{-1}$   
 What will be standard enthalpy of formation of H<sub>2</sub>O(l)?
- 13)  $\Delta_f H^\circ$  of Fe<sub>2</sub>O<sub>3</sub> is -825kJ. What is the enthalpy change for the reaction? 2  
 $4Fe_2O_3 \rightarrow 8Fe + 6O_2$
- 14) A swimmer coming out from a pool is covered with a film of water weighing about 18g. How much heat must be supplied to evaporate this water at 298 K? Calculate the internal energy of vaporisation at 100°C? 2  
 $\Delta_{vap} H^\circ$  for water at 373 K = 40.66 kJ mol<sup>-1</sup>
- 15) 18.0 g water completely vaporises at 100 °C and 1 bar pressure and the enthalpy change in the process is 40.79 KJ mol<sup>-1</sup>. What will be the enthalpy change for vaporising two moles of water under the same conditions? What is the standard enthalpy of vaporisation for water? 2
- 16) The enthalpy change for the reaction, 2  
 $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$ , is  $-154.40kJmol^{-1}$ . The formation of 2g of hydrogen expands the system by 22.4L at 1atm pressure.  
 What is the internal energy change of the reaction?
- 17) There are two crystalline forms of PbO; one is yellow and the other is red. The standard enthalpies of formation of these two forms are -217.3 kJ/mol and -219.0 kJ/mol respectively. Calculate the enthalpy change for the solid-solid phase transition. PbO (yellow) → PbO (red) 2
- 18) Predict in which of the following, entropy increases/decreases. Give reason. 2  
 Temperature of crystalline solid is raised from 0 K to 115K.
- 19) When 0.532 g of benzene (C<sub>6</sub>H<sub>6</sub>), boiling point 353 K, is burnt with excess of oxygen in a constant volume system, 22.3 KJ of heat is given out. Calculate  $\Delta H$  for the combustion process (R=8.31 J K<sup>-1</sup> mol<sup>-1</sup>) 2
- 20) Predict in which of the following, entropy increases/decreases. Give reason. 2  
 $H_2(g) \rightarrow 2H(g)$

**Section-C**

- 21) Compound with carbon-carbon double bond, such as ethylene, C<sub>2</sub>H<sub>4</sub>, add hydrogen in a reaction called hydrogenation, 5  
 $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$   
 Calculate enthalpy change for the reaction, using the following combustion data  
 $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l); \Delta_c H^\circ = -1401 \text{ kJmol}^{-1}$ ..... (i)  
 $C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l); \Delta_c H^\circ = -1550 \text{ kJmol}^{-1}$ ..... (ii)  
 $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l); \Delta_c H^\circ = -285.8 \text{ kJmol}^{-1}$ ..... (iii)
- 22) Write expression for the work done by 1 mole of the gas in each of the following case. 5
  - (i) For irreversible expansion of the gas from volume V<sub>1</sub> and V<sub>2</sub>.
  - (ii) For reversible isothermal expansion of the gas from volume V<sub>1</sub> and V<sub>2</sub>.
  - (iii) For expansion of the gas into an evacuated vessel.
  - (iv) For reversible isothermal compression of the gas from pressure p<sub>1</sub> and p<sub>2</sub>
  - (v) For adiabatic expansion resulting into change of temperature from T<sub>1</sub> and T<sub>2</sub>
- 23) The standard Gibbs energy change for the reaction N<sub>2</sub>(g) + 3H<sub>2</sub>(g) ⇌ 2NH<sub>3</sub>(g) is -33.2KJ mol<sup>-1</sup> at 298 K. 5  
 What would be the equilibrium constant if the reaction is written as  
 $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightleftharpoons NH_3(g)$

24) The figure given below represents pV diagram of different stages of a thermodynamic process. Calculate the work done in each stage and also the network done in the complete cyclic process.



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### Section-A

- 1) Specific heat,  $C = 4.18 \text{ Jg}^{-1} \text{ K}^{-1}$  (for water) Heat capacity,  $C_p = 18 \times 4.18 \text{ JK}^{-1} = 75.24 \text{ JK}^{-1}$  1
- 2) State function Enthalpy, entropy, temperature, free energy. Path function Heat, work. 1
- 3) For isolated system there is no transfer of energy as heat or work, so according to the first law of thermodynamics,  $\Delta U = q + W \Delta U = 0 + 0 = 0$  1
- 4) 1  
In an ideal gas, there are no intermolecular forces of attraction. Hence, no energy is required to overcome these forces. Moreover, when a gas expands against vacuum, work done is Zero (because  $p_{ext} = 0$ ). Hence, internal energy of the system does not change, i.e. there is neither absorption nor evolution of heat.
- 5) 1  
Most of the naturally occurring processes are accompanied by increase of randomness. Hence, randomness of the universe is continuously increasing. Thus, we are going towards chaos
- 6) 1  
Every substance has energy stored in it in the form of heat content. If heat content of reactants ( $H_R$ ) is greater than that of products ( $H_P$ ), heat is evolved. If  $H_R < H_P$ , heat is absorbed.
- 7) Enthalpy of vapourisation of water is more than that of acetone because there is strong hydrogen bonding in  $\text{H}_2\text{O}$  molecules. 1
- 8) Less the heat required to vaporise 1 mole of a liquid, less is its enthalpy of vaporisation. Hence, water has higher enthalpy of vaporisation. 1
- 9)  $\Delta_{sub}H^\circ = \Delta_{fus}H^\circ + \Delta_{vap}H^\circ = 2.6 + 98.2 = 100.8 \text{ KJ mol}^{-1}$  1
- 10)  $\Delta_f H^\circ$  for  $\text{Cl}_2(\text{g})$  will be zero but  $\Delta_f H^\circ$  for  $\text{Br}_2(\text{g})$  will not be zero because liquid bromine is its elementary state and not gaseous bromine. 1

### Section-B

- 11) 2  
 $\text{NO}(\text{g})$  is unstable because formation of  $\text{NO}$  is endothermic (energy is absorbed), but  $\text{NO}_2(\text{g})$  is formed because its formation is exothermic (energy is released). Therefore, unstable  $\text{NO}(\text{g})$  converts into stable  $\text{NO}_2(\text{g})$ .
- 12) 2  
Enthalpy of formation is the enthalpy change of the reaction when 1 mole of the compound is formed from its elements, i.e. we aim at  $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}), \Delta_f H^\circ = ?$  This can be obtained by dividing the given equation by 2. Hence,  $\Delta_f H^\circ (\text{H}_2\text{O}) = \frac{-572 \text{ KJ mol}^{-1}}{2} = -286 \text{ KJ mol}^{-1}$
- 13) 2
- 14) The process of evaporation can be represented as 2  

$$18\text{g } \text{H}_2\text{O}(\text{l}) \xrightarrow{\text{Vaporisation}} 18\text{g } \text{H}_2\text{O}(\text{g})$$
 Number of moles in  $18\text{g } \text{H}_2\text{O}(\text{l}) = \frac{18 \text{ g}}{18 \text{ g mol}^{-1}} = 1 \text{ mol}$   
 and  $\Delta_{vap}H^\circ$  is the amount of heat required to vaporise 1 mole of a substance. Thus,  $40.66 \text{ kJ mol}^{-1}$  heat is required for evaporation of 18 g of water.  
 Further, we know that  $\Delta_{vap}U = \Delta_{vap}H^\circ - p\Delta V = \Delta_{vap}H^\circ - \Delta_n RT$   
 (assuming steam behaving as an ideal gas).  
 $\therefore \Delta_{vap}U = 40.66 \text{ kJ mol}^{-1} - (1)(8.314 \text{ JK}^{-1} \text{ mol}^{-1})(373 \text{ K})(10^{-3})$   
 $\Delta_{vap}U = 40.66 \text{ kJ mol}^{-1} - 3.10 \text{ kJ mol}^{-1} = 37.56 \text{ kJ mol}^{-1}$
- 15)  $18.0 \text{ g } \text{H}_2\text{O} = 1 \text{ mol } \text{H}_2\text{O}$  2  
 Enthalpy change for vaporising 1 mole of  $\text{H}_2\text{O} = 40.79 \text{ KJ}$   
 $\therefore$  Enthalpy change for vaporising 2 moles of  $\text{H}_2\text{O} = 2 \times 40.79 \text{ KJ} = 81.58 \text{ KJ}$   
 Standard enthalpy of vaporisation at  $100^\circ\text{C}$  and 1 bar pressure,  
 $\Delta_{vap}H^\circ = +40.79 \text{ kJ mol}^{-1}$

16) 2

Taking the initial as negligible (as no gaseous reaction is present), change in volume during expansion ( $\Delta V = 22.4L$  . External pressure ( $p_{ext} = 1atm$  .  
 $\Delta H = \Delta U + p \Delta V$  or  $\Delta U = \Delta H - p \Delta V$   
 $\Delta U = 2307J - 2.31kJ$  therefore  $\Delta U = -154.4 - 2.31 = -156.71kJ$

17)  $-1.7 kJmol^{-1}$  2

18) 2

Entropy will increase on increasing the temperature since the particles of solid move with greater speed at higher temperature. At 0 K, there is perfect order of the constituent particles, entropy is minimum, tends to zero.

19)  $\Delta H = -3269 KJ$  2

20)  $H_2(g) \rightarrow 2H(g)$  2

Entropy will increase because the number of particles of product are double than that of reactant.

**Section-C**

21) 5

Adding Eqs.(i) and (iii) and subtract Eq.(ii),  
 $C_2H_4 + 3O_2(g) + H_2(g) + \frac{1}{2}O_2(g) - C_2H_6 - \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l) + H_2O(l) - 2CO_2(g) - 3H_2O(l)$  and  $\Delta_r H^\circ = -1401 kJ mol^{-1} - 286.0 kJ mol^{-1} - (-1550 kJ mol^{-1})$   
These equations give,  $C_2H_4 + H_2(g) \rightarrow C_2H_6(g)$ ;  $\Delta_r H^\circ = -137 kJ mol^{-1}$

22) 5

23) 5

For the given reaction,  
 $\Delta G^\circ = \frac{1}{2} X - 33.2 = 16.6 kJ mol^{-1}$  or  $\log K = -\frac{16.6 \times 10^3 J mol^{-1}}{2.303 \times (8.314 J K^{-1} mol^{-1}) \times (298K)}$   
 $\log K = 2.91$  or  $K = 8.1 \times 10^2$

24) 5

Process A  $\rightarrow$  B (expansion),  $p = 12 \times 10^5 Nm^{-2}$ ,  $\Delta V = 8 - 2 = 6L$   $\Delta U = 6 \times 10^5 J$  therefore  $W = -p \Delta V = -12 \times 10^5 \times 6 = -7200 J$   
Process B  $\rightarrow$  C. No change in volume, i.e.  $\Delta V = 0$  therefore  $W = 0$   
Process C  $\rightarrow$  D (contraction),  $\Delta V = 8 - 2 = 6L = 6 \times 10^{-3} m^3$ ,  $p = 4 \times 10^5 Nm^{-2}$   $W = p \Delta V = 4 \times 10^5 \times 6 \times 10^{-3} = 2400 J$   
Process D  $\rightarrow$  A. No change in volume, i.e.  $\Delta V = 0$  therefore  $W = 0$  therefore Net work done =  $-7200 + 2400 J = -4800 J$  Minus sign shows that net work has been done by the gas.