

QB365  
Model Question Paper 2

11th Standard CBSE

Chemistry

Reg.No. : 

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Time : 02:00:00 Hrs

Total Marks : 100

**Section-A**

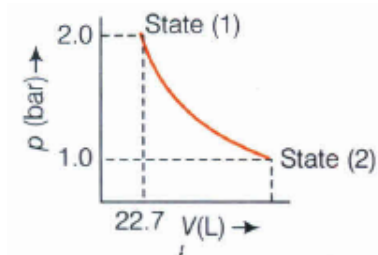
- 1) Heat capacity (Cp) is an extensive property but specific heat (C) is an intensive property. What will be the relation between Cp and C for 1mole of water? 1
- 2) Identify the state functions and path functions out of the following. Enthalpy, entropy, heat, temperature, work, free energy. 1
- 3) 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
- 4) At 1 atm will the  $\Delta_f H^\circ$  be zero for  $\text{Cl}_2(\text{g})$  and  $\text{Br}_2(\text{g})$ ? Explain. 1
- 5) For the reaction,  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$  the standard free energy is  $\Delta G^\ominus > 0$ . How is the equilibrium constant effected? 1
- 6) Ice melts slowly at higher altitudes. Explain why? 1
- 7) Which of the following are Lewis acids?  $\text{H}_2\text{O}, \text{BF}_3, \text{H}^+, \text{NH}_4^+$   
Lewis acids have a tendency to accept electrons. Electron deficient or positively charged species have such tendency. 1
- 8) In the reaction,  $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$  which species is oxidised? 1
- 9) Define the term reducing agent in term or loss of electrons. 1
- 10) What would happen if no salt bridge were used in the electrochemical cell (e.g. Zn - Cu cell)? 1
- 11) Name the isotope of hydrogen which contains equal number of protons and neutrons. 1
- 12) Arrange  $\text{H}_2$ ,  $\text{D}_2$  and  $\text{T}_2$  in the decreasing order of their boiling points 1
- 13) With the help of suitable examples, explain the property of  $\text{H}_2\text{O}_2$  that is responsible for its bleaching action? 1
- 14) Name two compounds which retard the decomposition of  $\text{H}_2\text{O}_2$  solution. 1
- 15) Is demineralised or distilled water useful for drinking purposes? If not, how can it be made useful? 1
- 16) Which gaseous compound on treatment with dihydrogen produces methanol? 1
- 17) Explain  $E^\ominus$  for  $\text{M}^{2+}(\text{aq}) + 2\text{e} \longrightarrow \text{M}(\text{s})$  (where, M = Ca, Sr or Ba) is nearly constant. 1
- 18) Which member of the alkaline earth metals family has least reactivity 1
- 19) What is the mixture of  $\text{CaCN}_2$  and Carbon known as? 1
- 20) What is magnesia cement? Give its composition. 1

**Section-B**

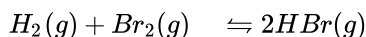
- 21) The enthalpy of a vaporisation of  $\text{CCl}_4$  is  $30.5 \text{ kJ mol}^{-1}$ . Calculate the heat required for the vaporisation of 284g of  $\text{CCl}_4$  at constant pressure (molar mass of  $\text{CCl}_4 = 154 \text{ g mol}^{-1}$ ) 2
- 22) Standard vaporisation enthalpy of benzene at boiling point is  $30.8 \text{ KJ mol}^{-1}$ . For how long would 100W electric heater have to operate in order to vaporise a 100g sample at that temperature (power=energy/time and  $1\text{W}=1\text{Js}^{-1}$ )? 2

- 23) Expansion of a gas in vacuum is called free expansion. Calculate the work done and the change in internal energy when 1L of ideal gas expands isothermally into vacuum until its total volume is 5 L? 2
- 24) The enthalpy change for the reaction, 2  
 $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$ , is  $-154.40 \text{ kJ mol}^{-1}$ . The formation of 2g of hydrogen expands the system by 22.4L at 1atm pressure.  
 What is the internal energy change of the reaction?
- 25) Enthalpies of formation  $Co(g)$ ,  $CO_2(g)$ ,  $N_2O(g)$  and  $N_2O_4(g)$  are -110, -393, 81 and  $9.7 \text{ kJ mol}^{-1}$  respectively. Find the value of  $\Delta_r H$  for the reaction. 2  
 $N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g)$
- 26) Predict in which of the following, entropy increases/decreases. 2  
 $H_2(g) \rightarrow 2H(g)$
- 27) At  $60^\circ \text{ C}$ , dinitrogen tetroxide is fifty per cent dissociated. Calculate the standard free energy change at this temperature and at one atmosphere. 2
- 28) Calculate the oxidation number of phosphorus in the following species. 2  
 $HPO_3^{2-}$
- 29) The reaction 2  
 $vCl_2(g) + 2OH^-(aq) \rightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$   
 represents the process of bleaching. Identify and name the species that bleaches the substances due to its oxidising action.  
 Write the oxidation number of each element above its symbol and then identify the bleaching reagent by observing the change in oxidation number.
- 30) Consider the reactions, 2  
 $C_6H_5CHO(l) + 2[Ag(NH_2)_2]^+(aq) + 30H^-(aq) \rightarrow C_6H_5COO^-(aq) + 2Ag(s) + 4NH_3(aq) + 2H_2O(l)$   
 What inference do you draw about the behaviour of  $Ag^+$  and  $Cu^{2+}$  from these reactions?  
 To find the behaviour  $Ag^+$  and  $Cu^{2+}$  in the given reactions, find whether there is addition of oxygen or any other electronegative element and addition of hydrogen or any other electropositive element. If there is addition of O to a reactant then other reactant acts as reducing agent (or reductant) and if there is addition of hydrogen, they act as oxidant.
- 31) Consider the elements: Cs, Ne, I and F. 2  
 Identify the element that exhibits only negative oxidation state.
- 32) Give reasons. 2  
 Ice floats on water
- 33) In the Solvay process, can we obtain sodium carbonate directly by treating the solution containing  $(NH_4)_2CO_3$  with sodium chloride? Explain. 2
- 34) Explain why can alkali and alkaline earth metals not be obtained by chemical reduction methods? 2
- 35) 10 moles of an ideal gas expand isothermally and reversibly from a pressure of 5 atm to 1 atm at 300 K. What is the largest mass that can be lifted through a height of 1 m by this expansion? 2
- 36) 1 mole of an ideal gas undergoes reversible isothermal expansion from an initial volume of  $V_1$  to a final volume of  $10V_1$  and does 10kJ of work. The initial pressure was  $1 \times 10^7 \text{ Pa}$ . Calculate  $V_1$  2

- 37) 1.0 mole of a monoatomic ideal gas is expanded from state (1) to state (2) as shown in figure. Calculate the work done for the expansion of gas from state(1) to state (2) at 298 K. 2



- 38) The equilibrium constant for the following reaction is  $1.6 \times 10^5$  at 1024 K 2



Find the equilibrium pressure of all gases if 10.0 bar of HBr is introduced into a sealed container at 1024 K

- 39) At 473K, equilibrium constant  $K_c$  for decomposition of phosphorus pentachloride  $PCl_5$  is  $8.3 \times 10^{-3}$ . If 2

decomposition is depicted as,



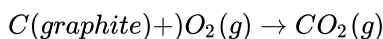
$$\Delta H^\circ = 124.0 \text{ kJmol}^{-1}$$

What is the value of  $K_c$  for the reverse reaction at the same temperature?

- 40) The solubility product of  $Al(OH)_3$  is  $2.7 \times 10^{-11}$  2

Calculate its solubility ( $\text{mg L}^{-1}$ ) and also find out pH of this solution. (Atomic mass of Al = 27u)

- 41) 1g of graphite is burnt in a bomb calorimeter in excess of oxygen at 298K and 1 atmospheric pressure according to the equation 2



During the reaction, temperature rises from 298K to 299K. If the heat capacity of the bomb calorimeter is 20.7kJ/K, what is the enthalpy change for the above reaction at 298K and 1 atm?

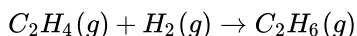
### Section-C

- 42) Express the change in internal energy of a system when 5

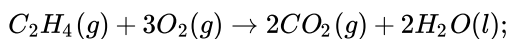
No heat is absorbed by the system from the surroundings, but work (W) is done on the system. What type of wall does the system have?

- 43) Compound with carbon-carbon double bond, such as ethylene,  $C_2H_4$ , add hydrogen in a reaction called 5

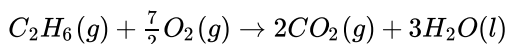
hydrogenation,



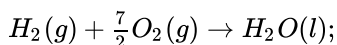
Calculate enthalpy change for the reaction, using the following combustion data



$$\Delta_c H^\circ = -1401 \text{ kJmol}^{-1} \dots \dots \dots (i)$$



$$\Delta_c H^\circ = -1550 \text{ kJmol}^{-1} \dots \dots \dots (ii)$$



$$\Delta_c H^\circ = -286.0 \text{ kJmol}^{-1} \dots \dots \dots (iii)$$

- 44) Two moles of a perfect gas undergo the following processes. 5

(i) a reversible isobaric expansion from (1.0 atm, 20.0 L) to (1.0 atm, 40.0 L)

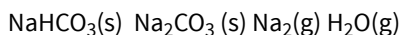
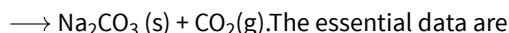
(ii) a reversible isochoric change of state from (1.0 atm, 40.0 L) to (0.5 atm, 40.0 L)

(iii) a reversible isothermal compression from (0.5 atm, 40.0 L) to (1.0 atm, 20.0 L)

Answer the question related to the above processes.

What will be the value of  $\Delta U$ ,  $\Delta H$  and  $\Delta S$  for the overall process?

45) Sodium carbonate,  $\text{Na}_2\text{CO}_3$  can be obtained by heating sodium hydrogen carbonate,  $\text{NaHCO}_3$  as  $2 \text{NaHCO}_3(\text{s})$  5

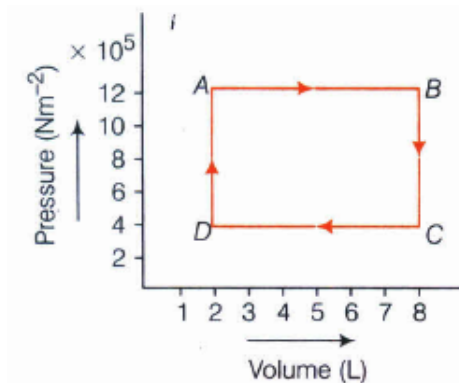


$\Delta_f H^\circ (\text{KJ mol}^{-1})$  -947.7 -1130.9 -393.51 -241.82

$S_m^\circ (\text{J mol}^{-1})$  102.1 136 188.83 213.74

Calculate the temperature above which  $\text{NaHCO}_3$  decomposes to give products at 1 bar.

46) 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. 5



47) Calculate the degree of ionisation of 0.05M acetic acid if its  $\text{pK}_a$  value is 4.74. How is the degree of dissociation affected when its solution also contains 5

0.1M

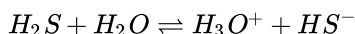
$\alpha$  is related to  $K_a$  as  $\alpha = \sqrt{\frac{K_a}{C}}$ , so first find  $K_a$  from  $\text{pK}_a$  as  $\text{pK}_a = -\log$

$(K_a)$  and then calculate  $\alpha$ .

To find  $\alpha$  in the presence of 0.01 M HCl or 0.1 M HCl, calculate  $C\alpha$  for acetate ions by taking  $[\text{H}^+]$  ion concentrations 0.01M or 0.1M.

48) The first ionisation constant on  $\text{H}_2\text{S}$  is  $9.1 \times 10^{-8}$ . Calculate the concentration of  $\text{HS}^-$  ion in its 0.1 M solution. How will this concentration be affected if the solution is 0.1 M in HCl also? If the second dissociation constant of  $\text{H}_2\text{S}$  is  $1.2 \times 10^{-13}$ , calculate the concentration of  $\text{S}^{2-}$  under both conditions. 5

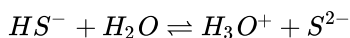
$\text{H}_2\text{S}$  being a weak acid, dissociates as



$\therefore K_a = \frac{[\text{H}_3\text{O}^+][\text{HS}^-]}{[\text{H}_2\text{S}]}$

HCl being a strong acid dissociates completely, so calculate  $[\text{HS}^-]$  in the presence of 0.1M HCl by taking  $[\text{HS}^-]$  concentration as 0.1M.

Calculate  $[\text{S}^{2-}]$  ion concentration by using the equation,



Calculate the  $[\text{S}^{2-}]$  ion concentration in the presence of 0.1M HCl.

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### Section-A

1) Specific heat,  $C = 4.18 \text{Jg}^{-1} \text{K}^{-1}$  (for water) 1

Heat capacity,  $C_p = 18 \times 4.18 \text{JK}^{-1} = 75.24 \text{JK}^{-1}$

2) State function Enthalpy, entropy, temperature, free energy. Path function Heat, work. 1

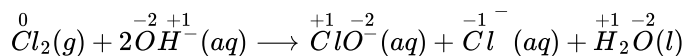
- 3) 1  
 Less the heat required to vaporise 1 mole of a liquid, less is its enthalpy of vaporisation. Hence, water has higher enthalpy of vaporisation.
- 4) 1  
 $\Delta_f H^\circ$  for  $\text{Cl}_2(\text{g})$  will be zero but  $\Delta_f H^\circ$  for  $\text{Br}_2(\text{g})$  will not be zero because liquid bromine is its elementary state and not gaseous bromine.
- 5) 1  
 $\Delta G^\ominus$  and K are related as  $\Delta G^\ominus = -RT \ln K_c$ . When  $G^\ominus > 0$  means  $\Delta G^\ominus$  is a positive. This can be so only if  $\ln K_c$  is negative i.e.  $K_c < 1$ .
- 6) 1  
 $\text{Ice(s)} \rightarrow \text{Water}$  The melting of ice is favoured at high pressure because there is decrease in volume in the forward reaction. Since at high altitudes, atmospheric pressure is low and therefore, ice melts slowly.
- 7)  $\text{BF}_3$ ,  $\text{H}^+$  and  $\text{NH}_4^+$  act as Lewis acids. 1
- 8) 1
- 9) 1
- 10) 1  
 If no salt bridge is used, the positive ions (i.e.  $\text{Zn}^{2+}$ ) formed by loss of electrodes will assemble around the zinc electrode and negative ions (i.e.  $\text{SO}_4^{2-}$ ) left after reduction of  $\text{Cu}^{2+}$  ions will accumulate around the copper electrode. Thus, the solution will develop charges. Further, since the inner circuit is not complete, the current stops flowing.
- 11) 1  
 Deuterium ( ${}^2_1\text{H}$ ) Number of protons (p) = number of electrons = atomic number = 1  
 Number of neutrons (n) = Mass number - atomic number = 2 - 1 = 1
- 12)  $\text{T}_2 > \text{D}_2 > \text{H}_2$  1
- 13) 1
- 14) 1
- 15) 1  
 Demineralised or distilled water is not useful for drinking purposes. It can be made useful by adding useful minerals in proper amount.
- 16) Carbon monoxide 1
- 17) 1  
 $E^\circ$  for  $\text{M}^{2+}(\text{aq}) + 2\text{e} \rightarrow \text{M}(\text{s})$  (where, M = Ca, Sr or Ba) is almost same because,  $E^\circ$  of any  $\text{M}^{2+}/\text{M}$  electrode depends upon three factors (i) enthalpy of vaporisation, (ii) ionisation enthalpy (iii) enthalpy of hydration. Since the combined effect of these factors is approximately the same for Ca, Sr and Ba, therefore, their electrode potentials are nearly constant.
- 18) Be 1
- 19) A mixture of calcium cyanamide ( $\text{CaCN}_2$ ) and carbon is known as nitrolim. It is used as a fertiliser. 1
- 20) 1  
 When a saturated solution of magnesium chloride is mixed with magnesium oxide, it sets to a hard mass. This hard mass is known as magnesia cement. Its composition is  $\text{MgCl}_2 \cdot 5 \text{MgO} \cdot \text{H}_2\text{O}$ .

### Section-B

- 21) 1 mole of  $\text{CCl}_4 = 154 \text{ g}$  2  
 Heat required for vapourising 154 g  $\text{CCl}_4 = 30.5 \text{ kJ}$   
 $\therefore$  Heat required for vapourising  
 $284 \text{ g } \text{CCl}_4 = \frac{30.5 \times 284}{154} \text{ kJ} = 56.25 \text{ kJ}$
- 22)  $\Delta_{\text{vap}} H^\circ(\text{benzene}) = 30.8 \text{ kJ mol}^{-1}$  2  
 Molar mass of benzene,  
 $\text{C}_6\text{H}_6 = (6 \times 12 + 6 \times 1) \text{ g mol}^{-1} = 78 \text{ g mol}^{-1}$   
 Energy needed to vaporise benzene 394  
 $= 30.8 \text{ kJ mol}^{-1} \times \frac{100 \text{ g}}{78 \text{ g mol}^{-1}} = 39.49 \text{ kJ}$  So  $\text{Time} = \frac{\text{energy}}{\text{power}} = \frac{39.49 \text{ kJ}}{100 \text{ W}} = \frac{39.49 \times 10^3 \text{ J}}{100 \text{ Js}^{-1}}$   
 $= 394.9 \text{ s} = 6.6 \text{ min}$
- 23) *Work done*,  $W = -p_{\text{ext}}(V_2 - V_1)$  2  
 As  $p_{\text{ext}} = 0$ , so  $w = -0(5 - 1) = 0$   
 For *isothermal expansion*,  
 $\Delta U = 0$  as  $\Delta T = 0$
- 24) 2  
 Taking the initial as negligible (as no gaseous reaction is present), change in volume during expansion  
 $(\Delta V) = 22.4 \text{ L}$ . External pressure ( $p_{\text{ext}} = 1 \text{ atm}$ ).  
 $\Delta H = \Delta U + p\Delta V$  or  $\Delta U = \Delta H - p\Delta V$   
 $p\Delta V = 1 \text{ atm} \times 22.4 \text{ L} = 22.4 \text{ Latm}$   
 $= 22.4 \times 101.3 \text{ J}$   
 $= 2307 \text{ J} = 2.31 \text{ kJ}$   
 $\therefore \Delta U = -154.4 - 2.31 = -156.71 \text{ kJ}$
- 25) Heat of reaction, 2  
 $\Delta_r H^\circ = \Sigma \Delta_f H^\circ_{\text{products}} - \Sigma \Delta_f H^\circ_{\text{reactants}}$   
 $= [\Delta_f H^\circ(\text{N}_2\text{O}) + 3\Delta_f H^\circ(\text{CO}_2)] - [\Delta_f H^\circ(\text{N}_2\text{O}_4) + 3\Delta_f H^\circ(\text{CO})]$   
 $= [81 + (3 \times -393)] - [9.7 + (3 \times -110)] \text{ kJ}$   
 $= -777.7 \text{ kJ} \approx -778 \text{ kJ}$
- 26) 2  
 At reactant side, there is only one gaseous molecule and at product side there are two gaseous atoms. Thus, randomness is more towards product side, i.e. entropy of two moles of H-atoms is higher than one mole of dihydrogen molecule.
- 27)  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$  2  
 If  $\text{N}_2\text{O}_4$  is 50% dissociated,  
 $x_{\text{N}_2\text{O}_4} = \frac{1-0.5}{1+0.5} \Rightarrow x_{\text{NO}_2} = \frac{2 \times 0.5}{1+0.5}$   
 $p_{\text{N}_2\text{O}_4} = \frac{0.5}{1.5} \times 1 \text{ atm}$ ,  $p_{\text{NO}_2} = \frac{1}{1.5} \times 1 \text{ atm}$   
 The equilibrium constant  $K_p$  is given by  
 $K_p = \frac{(p_{\text{NO}_2})^2}{p_{\text{N}_2\text{O}_4}} = \frac{1.5}{(1.5)^2(0.5)} = 1.33 \text{ atm}$   
 Since,  $\Delta_r G^\circ = -RT \ln K_p$   
 $\Delta_r G^\circ = (-8.314 \text{ JK}^{-1} \text{ mol}^{-1}) \times (333 \text{ K}) \times (2.303) \times (0.1239)$   
 $= -763.8 \text{ kJmol}^{-1}$
- 28) Suppose that the oxidation number of P in  $\text{HPO}_3^{2-}$  be x. 2  
 Theb,  $1+x+3(-2)=-2$   
 or  $x+1-6=-2$  or  $x=+3$

29)

2



In this reaction, oxidation number of Cl increases from 0 (in  $\text{Cl}_2$ ) to 1 (in  $\text{ClO}^-$ ) as well as decreases from 0 (in  $\text{Cl}_2$ ) to -1 (in  $\text{Cl}^-$ ). So, it acts as both reducing as well as oxidising agent. This is an example of disproportionation reaction. In this reaction,  $\text{ClO}^-$  species bleaches the substances due to its oxidising action. [In hypochlorite ion ( $\text{ClO}^-$ ), Cl can decrease its oxidation number from +1 to 0 or -1].

**Note**

Disproportionation reactions are a special type of redox reactions in which an element in one oxidation state is simultaneously oxidised and reduced.

30) In reaction  $[\text{Ag}(\text{NH}_3)_2]^+(\text{aq})$  oxidises benzaldehyde to benzoic acid but in reaction

2

31) F exhibits only negative oxidation state because it is the most electronegative element.

2

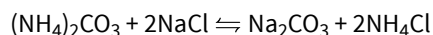
32) Density of ice is less than that of liquid water, so it floats over water.

2

33)

2

No,  $(\text{NH}_4)_2\text{CO}_3$  reacts with NaCl as



Because the products obtained  $\text{Na}_2\text{CO}_3$  and  $\text{NH}_4\text{Cl}$  are highly soluble and the equilibrium will not shift in forward direction. That's why in the Solvay process, we cannot obtain sodium carbonate directly by treating the solution containing  $(\text{NH}_4)_2\text{CO}_3$  with sodium chloride.

34)

2

(i) Alkali and alkaline earth metals are themselves strong reducing agents. Therefore, these metals cannot be obtained by chemical reduction of their oxides and other compounds.

(ii) These metals are highly electropositive in nature. So these cannot be displaced from the aqueous solutions of their salts by other metals.

35)  $W_{\text{exp}} = -2.303 nRT \log \frac{p_1}{p_2}$ 

2

$$= -2.303(10) \times (8.314)(300) \log \frac{1}{5} = -40.15 \times 10^3 \text{ J} \quad [1]$$

If M is the mass that can be lifted by this work through a height of 1 m, then work done = Mgh

$$40.15 \times 10^3 \text{ J} = M \times 9.81 \times m \text{ s}^{-1} \times 1 \text{ m}$$

$$\text{or } M = \frac{40.15 \times 10^3 \text{ kg} \cdot \text{m}^2 \text{ s}^{-2}}{9.81 \text{ m s}^{-2} \times 1 \text{ m}} \quad (\because J = \text{kg m}^2 \text{ s}^{-2})$$

$$= 4092.76 \text{ kg}$$

36) We know that  $w = -2.303nRT \log \frac{V_2}{V_1}$ 

2

$$10 \times 10^3 \text{ J} = 2.303 \times 1 \times 8.314 \times T \times \log \frac{10V_1}{V_1}$$

$$\text{or } T = 522.3 \text{ K}$$

For initial conditions,  $p_1 V_1 = n_1 RT$ ,

$$\text{i.e. } (10^7 \text{ Pa}) V_1 = 1 \times 8.314 \times 522.3$$

$$\text{or } V_1 = 4.342 \times 10^{-4} \text{ m}^3 = 4.342 \times 10^2 \text{ cm}^3$$

$$= 434.2 \text{ cm}^3$$

We cannot apply the formula  $-w = p \Delta V$  because expansion is not against constant pressure.)

37)

2

The given diagram represents that the process is carried out in infinite steps, hence, it is isothermal reversible expansion of the ideal gas from pressure 2.0 atm to 1.0 atm at 298 K.

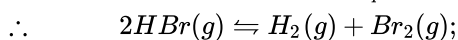
$$W = -2.303 nRT \log \frac{p_1}{p_2}$$

$$W = -2.303 \times 1 \text{ mol} \times 8.314 \text{ JK}^{-1} \text{ mol}^{-1} \times 298 \text{ K} \log 2 \quad \left( \because \frac{p_1}{p_2} = \frac{2}{1} \right)$$

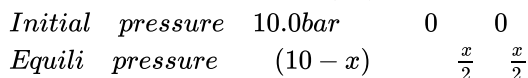
$$w = -1717.63 \text{ J}$$

38)  $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$ ; 2

$$K_p = 1.6 \times 10^5 \text{ at } 1024K$$



$$K_p' = \frac{1}{1.6 \times 10^5} \text{ at } 1024 K$$



$$K_p = \frac{p_{H_2} p_{Br_2}}{p_{HBr}^2} = \frac{\frac{x}{2} \cdot \frac{x}{2}}{(10-x)^2}$$

$$\frac{1}{1.6 \times 10^5} = 0.625 \times 10^{-5} = \frac{\frac{x}{2} \cdot \frac{x}{2}}{10 \times 10}$$

[(10 - x) ≈ 10 because magnitude of  $K_p$  is small.]

$$2 \times 2 \times 10 \times 10 \times 0.625 \times 10^{-5} = x^2$$

or  $x = 0.050$

$$p_{H_2} = p_{Br_2} = \frac{x}{2} = \frac{0.050}{2} = 0.025 \text{ bar}$$

$$= 2.5 \times 10^{-2} \text{ bar}$$

$$p_{HBr} = 10 - 0.050 = 9.95$$

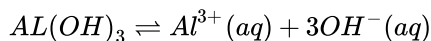
$$\approx 10 \text{ bar}$$

39)  $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ ;  $K_c = 8.3 \times 10^{-3}$  2

For the reverse reaction

$$K_c' = \frac{1}{K_c} = \frac{1}{8.3 \times 10^{-3}} = 120.48$$

40) Let S be the solubility of  $Al(OH)_3$  2



$$K_{sp} = [Al^{3+}][OH^-]^3 = (s)(3s)^3 = 27s^4$$

$$S^4 = \frac{K_{sp}}{27} = \frac{2.7 \times 10^{-11}}{27} = 1 \times 10^{-12};$$

$$S = 1 \times 10^{-3} \text{ mol L}^{-1}$$

Solubility of  $Al(OH)_3$

Molar mass of  $Al(OH)_3$  in  $g L^{-1}$

$$= 1 \times 10^{-3} \times 78 g L^{-1}$$

$$= 78 \times 10^{-3} g L^{-1}$$

pH of the solution  $S = 1 \times 10^{-3} \text{ mol L}^{-1}$

$$[OH^-] = 3s = 3 \times 1 \times 10^{-3} \text{ mol L}^{-1}$$

$$pH = 14 - pOH = 14 + \log 3 = 11.4771$$

41) In bomb calorimeter, volume remains constant, thus, the heat involved is internal energy. 2

Thus the combustion of the 1g of graphite

$$= -20.7 kJ K^{-1}$$

For combustion of 1 mole (12.0g) of graphite

$$= \frac{12.0 g mol^{-1} \times (-20.7 kJ)}{1 g}$$

$$= -2.48 \times 10^2 kJ mol^{-1},$$

$$\text{Since, } \Delta n_g = 0, \Delta H = \Delta U = -2.48 \times 10^2 kJ mol^{-1}$$

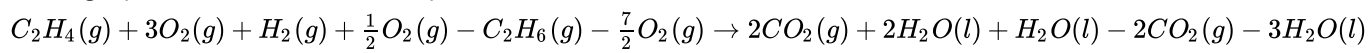
### Section-C

42) If heat absorbed is zero, i.e.  $q=0$  or the process is adiabatic, the first law reduces to 5

$$\Delta U = W_{ad}$$

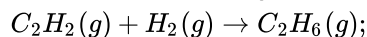


Adding Eqs.(i) and (iii) and subtract Eq.(ii),



$$\text{and } \Delta_r H^\circ = -1401 \text{ kJmol}^{-1} - 286.0 \text{ kJmol}^{-1} - (-1550 \text{ kJmol}^{-1})$$

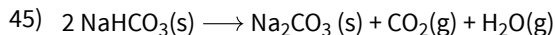
These equations give,



$$\Delta_r H^\circ = -137 \text{ kJmol}^{-1}$$

44)  $\Delta U = 0; \Delta H = 0; \Delta S = 0$

5



5

$$\Delta_r H^\circ = \Delta_f H^\circ(\text{Na}_2\text{CO}_3) + \Delta_f H^\circ(\text{CO}_2) + \Delta_r H^\circ(\text{H}_2\text{O}) - 2\Delta_f H^\circ(S_m^\circ(\text{NaHCO}_3))$$

$$= -1130 + (-393.51) + (-241.82) - 2X(-947.7)$$

$$= -1766.23 + 1895.4 = 129.17 \text{ kJmol}^{-1}$$

$$\Delta_r S^\circ = \Delta_r S_m^\circ(\text{Na}_2\text{CO}_3) + S_m^\circ(\text{CO}_2) + S_m^\circ(\text{H}_2\text{O}) - 2S_m^\circ(\text{NaHCO}_3)$$

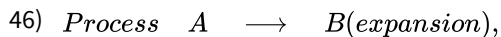
$$= 136.0 + 188.83 + 231.74 - 2X102.1$$

$$= 538.57 - 204.2 = 334.37 \text{ JK}^{-1}\text{mol}^{-1}$$

From second law of thermodynamics  $\Delta_r S^\circ = \frac{\Delta_r H^\circ}{T}$

$$\therefore T = \frac{\Delta_r H^\circ}{\Delta_r S^\circ} = \frac{129.17}{334.37 \times 10^{-3}} = 386.3 \text{ K}$$

Reaction will be spontaneous above 386.3 K.



5

$$p = 12 \times 10^5 \text{ Nm}^{-2}, \Delta V = 8 - 2 = 6 \text{ L}$$

$$= 6 \times 10^{-3} \text{ m}^3$$

$$\therefore \text{Work done} = -p\Delta V$$

$$= -(12 \times 10^5) \times (6 \times 10^{-3}) \text{ J} = -7200 \text{ J}$$

*Process B*  $\rightarrow$  *C.No change in volume, i.e.  $\Delta V = 0$*

$$\therefore \text{Work done} = 0$$

*Process C*  $\rightarrow$  *D(contraction)*

$$\Delta V = 8 - 2 = 6 \text{ L} = 6 \times 10^{-3} \text{ m}^3, p = 4 \times 10^5 \text{ Nm}^{-2}$$

*Work done*

$$p\Delta V = (4 \times 10^5) (6 \times 10^{-3}) = 2400 \text{ J}$$

*Process D*  $\rightarrow$  *A. No change in volume, i.e.  $\Delta V = 0$*

$$\therefore \text{Work done} = 0$$

$\therefore$  *Net work done in the complete cyclic process*

$$= -7200 + 2400 \text{ J} = -4800 \text{ J}$$

*Minus sign shows that net work has been done by the gas.*

$$47) \because pK_a = -\log K_a$$

$$\because 4.74 = -\log K_a$$

$$\text{or } K_a = \text{antilog } \bar{5}.26 = 1.82 \times 10^{-5}$$

$$\text{From } \alpha = \sqrt{\frac{K_a}{C}}$$

$$\alpha = \sqrt{\frac{1.82 \times 10^{-5}}{0.05}} = \sqrt{0.364 \times 10^{-3}} = \sqrt{3.64 \times 10^{-4}}$$

$$\alpha = 1.908 \times 10^{-2}$$

In the presence of 0.1 M HCl

$$\text{Similarly, } K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

$$1.82 \times 10^{-5} = \frac{C\alpha \times 0.1}{0.05}$$

$$[H^+] = (C\alpha + 0.1M) \approx 0.1M$$

(because 0.1M HCl = 0.1 M H<sup>+</sup> ions)

$$C\alpha = \frac{1.82 \times 10^{-5} \times 0.05}{0.1} = 0.91 \times 10^{-5}$$

$$\alpha = \frac{0.91 \times 10^{-5}}{0.05} = 1.82 \times 10^{-4}$$

In the presence of strong acid, dissociation of weak acid i.e. CH<sub>3</sub>COOH decreases due to common ion effect.

48) In the presence of 0.1M HCl,

$$K_{a2} = \frac{[H_3O^+][S^{2-}]}{[HS^-]} = \frac{[0.1][S^{2-}]}{[9.1 \times 10^{-8}]}$$

$$[S^{2-}] = 1.092 \times 10^{-19} M$$