

Class: 11
Subject: Chemistry
Topic: OASK1511SA102
No. of Questions: 26

Q1. At 27°C K_p value for reaction $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ is 0.1 atm, calculate its K_c value.

Sol. $K_p = K_c(RT)^{\Delta n}$

$$\Delta n = 1$$

$$K_c = \frac{K_p}{RT} = \frac{0.1}{0.82 \times 300} = 4 \times 10^{-3}$$

Q2. Arrange the bonds in order of increasing ionic character in the molecules:

LiF, K_2O , N_2 , SO_2 and ClF_3

Sol. $\text{N}_2 < \text{ClF}_3 < \text{SO}_2 < \text{K}_2\text{O} < \text{LiF}$

Q3. Which is the stronger base towards a proton NH_2^- or PH_2^- and why?

Sol. Bond energy ($\text{N}-\text{H} > \text{P}-\text{H}$) ionisation suggests that NH_2^- will be stronger base. This is consistent with the relative strengths of the respective conjugate acids: $\text{NH}_3 < \text{PH}_3$.

Q4. What is the atomic number of the element having maximum number of unpaired 2p electrons?
To which group it belong?

Sol. ${}^7\text{N}$. It belong to 15 (or VA gp) group.



Q5. The law of multiple proportions is illustrated by the pair of compounds:

- (a) sodium chloride and sodium bromide
- (b) water and heavy water
- (c) sulphur dioxide and sulphur trioxide
- (d) magnesium hydroxide and magnesium oxide

Sol. (c)

In SO_2 32 gram of sulphur react with 32 gram of oxygen. Similarly for SO_3 fixed mass of sulphur (32 gram) react with 48 gram of oxygen. The ratio of oxygen's mass = 32:48 = 2:3

Which support law of multiple proportions.

Q6. Why bond angle in NH_3 is 107° while in H_2O it is 104.5° ?

Sol. In NH_3 , central nitrogen atom bears only one lone pair of electrons whereas in H_2O central oxygen atom bears two lone pair of electrons. Since the repulsion between lone pair-lone pair and lone pair – bond pair is more than that between bond pair-bond pair, the repulsion in H_2O is much greater than that in NH_3 which results in contraction of bond angle from $109^\circ 28''$ to 104.5° in water while in NH_3 contraction is less i.e. from $109^\circ 28''$ to 107° .

Q7. Compare the size of Cl , Cl^- , and Fe^{++} ion

Sol. $\frac{Z}{e}$ ratio for $\text{Cl} = \frac{17}{17} = 1.00$

$$\text{Cl}^- = \frac{17}{18} = 0.944 \quad \text{and} \quad \text{Fe}^{++} = \frac{26}{24} = 1.08$$

$$\text{Cl}^- > \text{Cl} > \text{Fe}^{++}$$

Q8. 5.2 g of CaCO_3 when heated produced 1.99 g of Carbon dioxide and the residue (CaO) left behind weighs 3.2g. Show that these results illustrate the law of conservation of mass.

Sol. Weight of CaCO_3 taken = 5.2 g

Total weight of the products ($\text{CaO} + \text{CO}_2$) = 3.20 + 1.99 = 5.19 g

Difference between the wt. of the reactant and the total wt. of the products

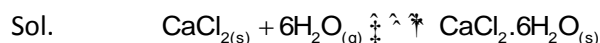
$$= 5.20 - 5.19 = 0.01 \text{ g.}$$

This small difference may be due to experimental error.

Thus law of conservation of mass holds good within experimental errors

- Q9. Anhydrous CaCl_2 is often used as desiccant. In presence of excess of CaCl_2 , the amount of water taken up is governed by $K_p = 1.28 \times 10^{85}$ for the following reaction at room temperature, $\text{CaCl}_{2(s)} + 6\text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CaCl}_2 \cdot 6\text{H}_2\text{O}_{(s)}$

What is the equilibrium pressure of water in a closed vessel that contains $\text{CaCl}_{2(s)}$?



$$\text{Here, } K_p = \frac{1}{(p_{\text{H}_2\text{O}})^6} = 1.28 \times 10^{85}$$

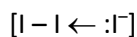
$$(p_{\text{H}_2\text{O}})^6 = \frac{1}{1.28} \times 10^{-85}$$

$$\therefore p_{\text{H}_2\text{O}} = \left[\frac{1}{1.28} \times 10^{-85} \right]^{\frac{1}{6}}$$

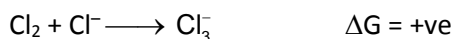
$$p_{\text{H}_2\text{O}} = 6.54 \times 10^{-15} \text{ atm}$$

- Q10. I_3^- is possible but not Cl_3^- . Why?

Sol. It is explained in terms of electronegativity and charge density of iodine and chlorine. And for the reaction,

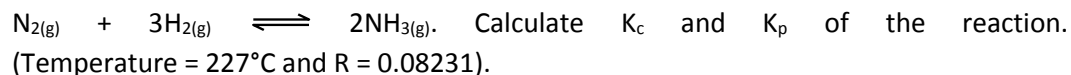


but for the reaction



Size of Cl is comparatively small and hence electronic repulsion make it non feasible.

Q11. One mole of N_2 is mixed with 3 moles of H_2 in a 4 litre container. If 25% of N_2 is converted into NH_3 by the following reaction



Sol. We have $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

Percentage N_2 reacted, 25%

$$\therefore x = 0.25$$

$$\text{Now, } (a - x) = 1 - 0.25 = 0.75$$

$$b - 3x = 3 - 0.75 = 2.25$$

$$\therefore \frac{(a - x)}{V} = \frac{0.75}{4} = 0.1875$$

$$\left(\frac{b - 3x}{V}\right) = \frac{2.25}{4} = 0.5625$$

$$\left(\frac{2x}{V}\right) = \frac{0.50}{4} = 0.125$$

$$\therefore K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.125)^2}{(0.1875)(0.5625)^3}$$

$$= 1.48 \times 10^{-5} \text{ L}^2 \text{ mol}^{-2}$$

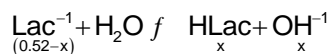
$$\text{Now, } K_p = K_c \cdot (RT)^{\Delta n} = 1.48 \times 10^{-5} \times [0.0821 \times (227 + 273)]^{-2}$$

$$\frac{1.48 \times 10^{-5}}{\{0.082 \times (500)\}^2}$$

$$= 8.78 \times 10^{-9}$$

Q12. Calcium lactate $Ca(\text{Lac})_2$ is salt of weak organic acid. A saturated solution of $Ca(\text{Lac})_2$ contains 0.13 mole of this salt in 0.5 litre solution. The pOH of this solution is 5.60. Assuming a complete dissociation of salt, calculate K_a of lactic acid.

Sol. $Ca(\text{Lac})_2 \rightleftharpoons Ca^{2+} + 2\text{Lac}^{-1}$
 $\frac{0.13}{2}$ $\frac{0.13 \times 2}{2}$



$$K_h = \frac{x^2}{0.52 - x} = \frac{x^2}{0.52} \text{ as } x \text{ is small}$$

$$[\text{OH}^{-1}] = 10^{-56} = 2.5 \times 10^{-6} = x$$

$$K_h = \frac{2.51 \times 10^{-6} \times 2.5 \times 10^{-6}}{0.52} = 12.12 \times 10^{-12}$$

$$K_a = \frac{K_w}{K_h} = \frac{10^{-14}}{12.12 \times 10^{-12}} = 8.26 \times 10^{-4}$$

Q13. What is the increase in volume when the temperature of 600 ml of air increases from 27°C to 47°C under constant pressure?

Sol. Charle's law is applicable as the pressure and amount remains constant.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } V_1 = \frac{T_1}{T_2} \times V_2$$

$$V_1 = \frac{320}{300} \times 600 = 640 \text{ ml}$$

$$\text{Increase in volume of air} = 640 - 600 = 40$$

Q14. How many protons, electrons and neutrons are present in 0.18 g $^{30}_{15}\text{P}$?

Sol. No. of neutrons in one atom = (30 - 15) = 15

$$0.18 \text{ g } ^{30}_{15}\text{P} = \frac{0.18}{30} = 0.006 \text{ mole}$$

$$\text{Now, number of } ^{30}_{15}\text{P} \text{ atoms in } 0.006 \text{ mole} = 0.006 \times 6.02 \times 10^{23}$$

$$\begin{aligned} \text{Number of electrons in } 0.006 \text{ mole of } ^{30}_{15}\text{P} &= \text{Number of protons in } 0.006 \text{ mole } ^{30}_{15}\text{P} \\ &= 15 \times 0.006 \times 6.02 \times 10^{23} = 5.418 \times 10^{22} \text{ and number of neutrons} = 5.418 \times 10^{22} \end{aligned}$$

Q15. What is the mass of 1 L of mercury in grams and in kilograms if the density of liquid mercury is 13.6 g cm^{-3} ?

Sol. We know the relationship, $1 \text{ L} = 1000 \text{ cm}^3$ and

$$\text{Also, density} = \frac{\text{mass}}{\text{volume}}$$

We can write, $\text{mass} = (\text{volume}) (\text{density})$

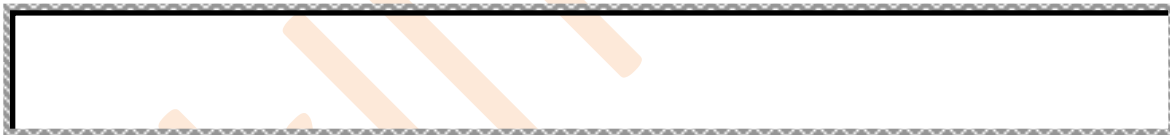
Therefore, the mass of 1 L of mercury is equal to

$$(1 \text{ L}) \left(\frac{1000 \text{ cm}^3}{1 \text{ L}} \right) (13.6 \text{ g cm}^{-3}) = (1000 \text{ cm}^3) (13.6 \text{ g cm}^{-3}) = 1.36 \times 10^4 \text{ g}$$

The mass in kilograms can be calculated as

$$1.36 \times 10^4 \text{ g} = (1.36 \times 10^4 \text{ g}) \left(\frac{1 \text{ kg}}{1000 \text{ g}} \right) = 13.6 \text{ kg}$$

(Remember, $\frac{1000 \text{ cm}^3}{1 \text{ L}}$ and $\frac{1 \text{ kg}}{1000 \text{ g}}$ are conversion factors with which we have to multiply for getting our answer in appropriate units).



Q16. When 1 mole of ice at 0°C and 4.6 mm of Hg is converted to water vapours at a constant temperature and pressure. Find ΔH and ΔE , if the latent heat of fusion of ice is 80 cal / gm and latent heat of vaporisation of liquid water at 0°C is 596 cal / gm . The volume of ice in comparison to volume of vapours may be neglected.

Sol. Ice \longrightarrow vapour

$$\Delta H = \Delta H_f + \Delta H_v$$

$$= 80 \times 18 + 596 \times 18$$

$$= 12168 \text{ cal / mole}$$

$$\Delta H = \Delta E + P\Delta V$$

ΔV = Volume of vapours at 4.6 mm and 0°C (as V_{ice} = negligible)

Now applying $PV = nRT$

$$P\Delta V = nRT = \frac{1 \times 8.314 \times 273}{4.18} \text{ cal} = 543 \text{ cal}$$

$$\Delta E = \Delta H - P\Delta V$$

$$= 12168 - 543$$

$$= 11625 \text{ cal}$$

Q17. A sample of gas occupies 100 litres at 1 atm pressure and at 0°C . If the volume of the gas is to be reduced to 5 litres at the same temperature, what additional pressure must be applied?

Sol. Here $P_1 = 1 \text{ atm}$ $P_2 = ?$
 $V_1 = 100 \text{ litre}$ $V_2 = 5 \text{ litre}$
 $T_1 = 273 \text{ K}$ $T_2 = 273 \text{ K}$

As temperature is constant

Then from Boyle's law

$$P_1V_1 = P_2V_2$$

$$\text{or } 1 \times 100 = P_2 \times 5$$

$$\therefore P_2 = 20 \text{ atm}$$

$$\therefore \text{Additional pressure that should be applied} = P_2 - P_1 = 20 - 1 = 19 \text{ atm}$$



Q18. When 2 g of gaseous substance A is introduced into an initially evacuated flask kept at 25°C , the pressure is found to be 1 atm. The flask is evacuated and 3 g of B is introduced. The pressure is found to be 0.5 atm at 25°C . Calculate the ratio $\frac{M_A}{M_B}$ (M – Molecular weight).

Sol. $PV = \frac{m}{M}RT$

$$\frac{P_A}{P_B} = \frac{m_A}{M_A} \times \frac{M_B}{m_B} \text{ (because V, R and T are constants)}$$

$$\frac{1}{0.5} = \frac{2}{M_A} \times \frac{M_B}{3}$$

$$\frac{M_A}{M_B} = \frac{1}{3}$$

Q19. The wave number of a radiation is 400 cm^{-1} . Find out its

- Wavelength
- Frequency
- J per photon
- kcal per mol of photons
- kJ per mol of photons

Sol. (a) $\bar{\nu} = \frac{1}{\lambda}$ or $\lambda = \frac{1}{\bar{\nu}} = \frac{1}{400 \text{ cm}^{-1}} = 2.5 \times 10^{-3} \text{ cm}$

(b) $\nu = \frac{c}{\lambda} = c \times \bar{\nu} = 3 \times 10^{10} \text{ cm/s} \times 400 \text{ cm}^{-1} = 1.2 \times 10^7 \text{ s}^{-1}$

(c) $E_{\text{photon}} = h\nu = \frac{hc}{\lambda} = h \times c \times \bar{\nu}$

$$= 6.626 \times 10^{-34} \text{ Js} \times 3 \times 10^8 \text{ cm/s} \times 400 \text{ cm}^{-1}$$

$$= 7.95 \times 10^{-21} \text{ J}$$

(d) $E_{\text{photon}} = 7.95 \times 10^{-21} \text{ J}$

$$\text{For 1 mol of photon energy} = 7.95 \times 10^{-21} \text{ J} \times 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$= (4.7875 \times 10^3 \text{ J mol}^{-1}) \text{ (1 kcal/4184 J)}$$

$$= 1.14 \text{ kcal mol}^{-1}$$

$$(e) E = (4.7875 \times 10^3 \text{ J mol}^{-1}) (1 \text{ kJ}/1000\text{J})$$

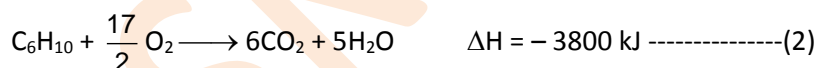
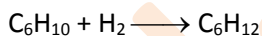
$$= 4.7875 \text{ kJ mol}^{-1}$$

Q20. The melting point of KCl is higher than that of AgCl though the crystal radii of Ag^+ and K^+ ions are almost same.

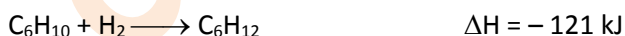
Sol. Now whenever any comparison is asked about the melting point of the compounds which are fully ionic from the electron transfer concept it means that the compound having lower melting point has got lesser amount of ionic character than the other one. To analyse such a question first find out the difference between the 2 given compounds. Here in both the compounds the anion is the same. So the deciding factor would be the cation. Now if the cation is different, then the answer should be from the variation of the cation. Now in the above example, the difference of the cation is their electronic configuration. $\text{K}^+ = [\text{Ar}]$; $\text{Ag}^+ = [\text{Kr}] 4d^{10}$. This is now a comparison between a noble gas core and pseudo noble gas core, the analysis of which we have already done. So try to finish off this answer.

Q21. The standard enthalpy of combustion of H_2 , C_6H_{10} and Cyclohexane (C_6H_{12}) are -241 , -3800 , $-3920 \text{ kJ mole}^{-1}$ at 25°C respectively. Calculate the heat of hydrogenation of cyclohexene.

Sol. We have to find ΔH for

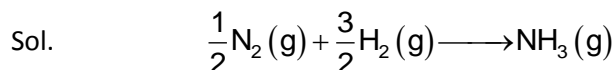
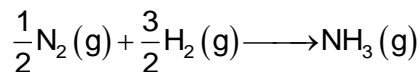


Adding equation (1) and (2) and then subtracting equation 3



\therefore Heat of hydrogenation of cyclohexene = -121 kJ

Q22. The standard heat of formation listed for gaseous NH_3 is -11.02 kcal/mol at 298 K. Given that at 298 K, the constant pressure heat capacities of gaseous N_2 , H_2 and NH_3 are respectively 6.96, 6.89, 8.38 cal/mol. Determine $\Delta H_{298\text{K}}^0$ and $\Delta H_{773\text{K}}$ for the reactions,



$$\Delta H_{298\text{K}} = \sum(\text{H}_f)_P - \sum(\text{H}_f)_R = -(11.02 - 0)$$

$$= -11.02 \text{ kcal mol}^{-1}$$

$$\frac{\Delta H_2 - \Delta H_1}{T_2 - T_1} = \Delta C_p$$

$$\frac{\Delta H_2 - (-11.02)}{773 - 298} = \left(8.38 - \frac{1}{2} \times 6.96 - \frac{3}{2} \times 6.89 \right) \times 10^{-3}$$

$$\Delta H_2 = -13.6 \text{ kcal mol}^{-1}$$

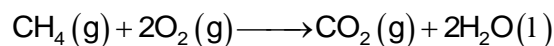
Q23. A sample of 0.16 g CH_4 was subjected to combustion at 27°C in a bomb calorimeter. The temperature of the calorimeter system (including water) was found to rise by 0.5°C . Calculate the heat of combustion of methane at (i) constant volume and (ii) constant pressure. The thermal capacity of calorimeter system is 17.7 kJ K^{-1} & $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$.

Sol. Heat of combustion at constant volume, $\Delta E = \text{Heat capacity of calorimeter system} \times \text{rise in temperature}$

$$\times \frac{\text{Mol. mass of compound}}{\text{mass of compound}}$$

$$= 17.7 \times 0.5 \times \frac{16}{0.16} = 885$$

$$\therefore \Delta E = -885 \text{ kJ mol}^{-1}$$



$$\Delta n = 1 - 3 = -2, T = 300 \text{ K}, R = 8.314 \times 10^{-3} \text{ kJ K}^{-1}\text{mol}^{-1}$$

$$\Delta H = \Delta E + \Delta nRT$$

$$\text{Since } \frac{\text{Total moles at equilibrium}}{\text{Total moles initially}} = \frac{\text{Vapour density initial}}{\text{Vapour density at equilibrium}}$$

$$\text{Initial vapour density} = \frac{92}{2} = 46$$

$$\frac{C(1+\alpha)}{C} = \frac{46}{d}$$

Since vapour density and actual density are related by the equation,

$$\text{V.D.} = \frac{\rho RT}{2P} = \frac{1.84 \times 0.082 \times 348}{2}$$

$$= 26.25$$

$$\therefore 1 + \alpha = \frac{46}{26.25} = 1.752$$

$$\therefore \alpha = 0.752$$

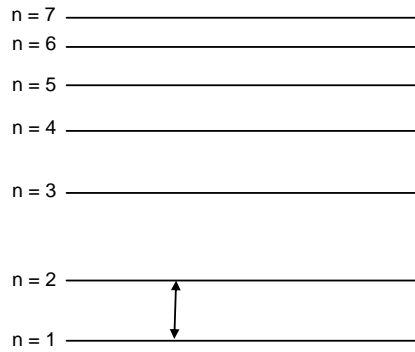
$$\therefore K_p = \frac{\left(\frac{2C\alpha}{C(1+\alpha)} \times P_T \right)^2}{\frac{C(1-\alpha)}{C(1+\alpha)} \times P_T} = \frac{\left(\frac{2 \times 0.75}{1.752} \times 1 \right)^2}{\frac{0.248}{1.752} \times 1}$$

$$= 5.2 \text{ atm}$$

Q26. Find out the longest wavelength of absorption line for hydrogen gas containing atoms in ground state.

Sol.
$$\frac{1}{\lambda} = RZ^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

For longest wavelength ΔE should be smallest, i.e. transition occurs from $n = 1$ to $n = 2$



$$\text{i.e. } \frac{1}{\lambda} = 109673 \text{ cm}^{-1} \times 1^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right]$$

$$\therefore \frac{1}{\lambda} = 109673 \times \frac{3}{4} \text{ cm}^{-1}$$

$$\therefore \lambda = \frac{4}{3 \times 109673 \text{ cm}^{-1}} = 1.2157 \times 10^{-5} \text{ cm} = 121.6 \text{ nm}$$