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CHEMISTRY
TARGET : JEE Advanced - 2023

CAPS – 5
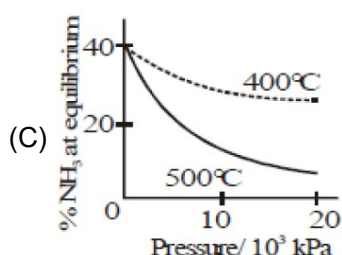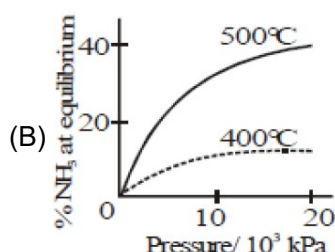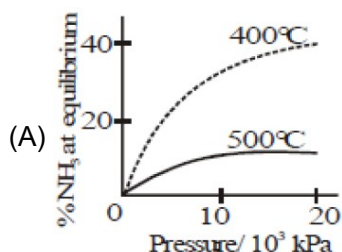## Chemical Equilibrium & Surface Chemistry

SINGLE CHOICE QUESTIONS

1. The percentage of ammonia obtainable, if equilibrium were to be established during the Haber process, is plotted against the operating pressure for two temperatures 400°C and 500°C. Which of the following correctly represents the two graphs?
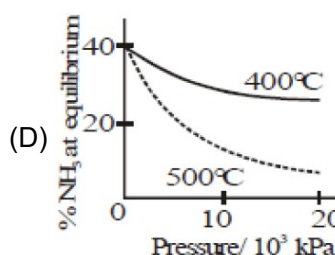
2. The value of kp for the reaction at 27oC $Br_2(\ell) + Cl_2(g) \rightleftharpoons 2BrCl(g)$ is '1 atm'. At equilibrium in a closed container partial pressure of BrCl gas is 0.1 atm and at this temperature the vapour pressure of $Br_2(\ell)$ is also 0.1 atm. Then what will be minimum moles of $Br_2(\ell)$ to be added to 1 mole of Cl_2, initially, to get above equilibrium situation?

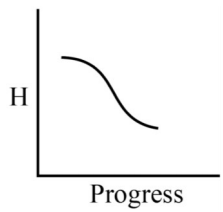   (A) $\frac{10}{6}$ moles   (B) $\frac{5}{6}$ moles   (C) $\frac{15}{6}$ moles   (D) 2 moles

3.
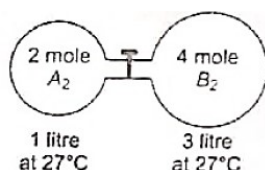
   The gas A_2 in the left flask allowed to react with gas B_2 present in right flask as

   $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$; Kc = 4 at 27oC.
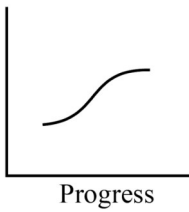
   What is the concentration of AB when equilibrium is established?

   (A) 1.33 M   (B) 2.66 M   (C) 0.66 M   (D) 0.33 M

4. For the reaction 2A(g) + B(g) $\rightleftharpoons$ C(g) + D(g); Kc = 10^{12}. If the initial moles of A, B, C and D are 2, 1, 7 and 3 moles respectively in a one litre vessel, what is the equilibrium concentration of A?

   (a) 4×10^{-4} (b) 2×10^{-4} (c) 10^{-4} (d) 8×10^{-4}

5. One mole of SO_3 was placed in a one litre vessel at a certain temperature. The following equilibrium was established in the vessel

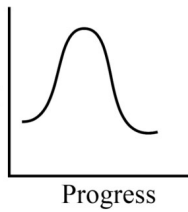$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

The equilibrium mixture reacts with 0.2 mole $KMnO_4$ in acidic medium. Hence, Kc is:

(A) 0.50   (B) 0.25   (C) 0.125   (D) None of these

6. Equilibrium constants of T_2O (T is $_3^1H$, an isotope of $_1^1H$) and H_2O are different at 298 K. Let at 298 K pure T_2O has pT (like pH) is 7.62. The pT of a solution prepared by adding 10 mL of 0.2 M TCl to 15 mL of 0.25 M NaOT is:

(A) $2 - \log 7$ (B) $14 + \log 7$ (C) $13.24 - \log 7$ (D) $13.24 + \log 7$

7. Identify the appropriate graph between enthalpy and progress of physical adsorption.
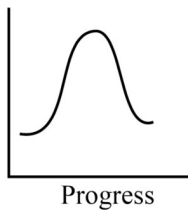

8. Which of the following is correct about lyophilic sols?

(A) They are irreversible.

(B) They are formed by inorganic substances.

(C) They are readily coagulated by addition of electrolytes.

(D) They are self-stabilized.

9. Below critical micelle concentration (CMC)

(A) The surfactant molecules of ions undergo association to form clusters.

(B) The viscosity of solution increases abruptly.

(C) Substances like grease, fat, etc., dissolve colloidally.

(D) Salt behaves as normal, strong electrolyte.

10. A detergent ($C_{12}H_{25}SO_4^-Na^+$) solution becomes a colloidal sol at a concentration of 10^{-3} M. On an average 10^{13} colloidal particles are present in 1 mm3. What is the average number of ions which are contained by one colloidal particle (micelle)?

[Given: $N_A = 6 \times 10^{23}$]

(A) 6×10^7 (B) 10   (C) 60   (D) None of these

MULTIPLE CHOICE QUESTIONS

11. A positive catalyst

(A) increases the average kinetic energy of reacting molecules

(B) decreases the activation energy

(C) can alter the reaction mechanism

(D) can change pre-exponential factor

12. Which of the following is correct about the chemical equilibrium?

(A) $(\Delta G)_{T,p} = 0$

(B) Equilibrium constant is independent of initial concentration of reactants

(C) Catalyst has no effect on equilibrium state

(D) Reaction stops at equilibrium

13. $N_2(g)$ and $H_2(g)$ are allowed to react in a closed vessel at given temp. and pressure for the formation of $NH_3(g)$ [$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 22.4$ kcal]. If He(g) is added at equilibrium at constant pressure, then which is/are correct?

(A) Concentration of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ decrease instantly.

(B) Moles of $NH_3(g)$ decrease

(C) The extent of cooling depends on amount of He(g) added.

(D) Concentration of N_2 and H_2 increases and concentration of NH_3 decreases.

14. If two gases AB_2 and B_2C are mixed the following equilibria are readily established

$AB_2(g) + B_2C(g) \rightleftharpoons AB_3(g) + BC(g)$

$BC(g) + B_2C(g) \rightleftharpoons B_3C_2(g)$

It the reaction is started only with AB_2 with B_2C, then which of the following is necessarily true at equilibrium:

(A) $[AB_3]_{eq} = [BC]_{eq}$ (B) $[AB_2]_{eq} = [B_2C]_{eq}$ (C) $[AB_3]_{eq} > [B_3C_2]_{eq}$ (D) $[AB_3]_{eq} > [BC]_{eq}$

15. Phase diagram of CO_2 is shown as following
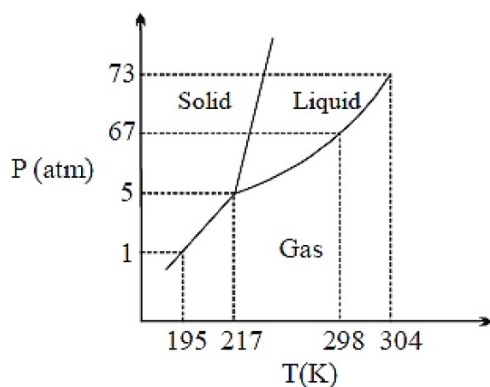
Based on above find the correct statement(s)

(A) 298 K is the normal boiling point of liquid CO_2

(B) At 1 atm & 190 K CO_2 will exist as gas.

(C) $CO_2(s)$ will sublime above 195 K under normal atmospheric pressure.

(D) Melting point & boiling point of CO_2 will increase on increasing pressure.
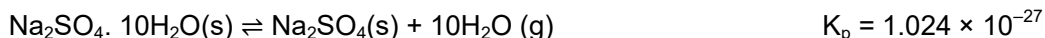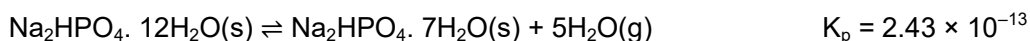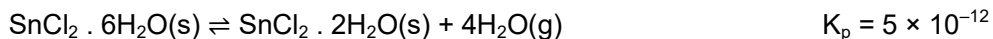
16. The equilibrium between, gaseous isomers A, B and C can be represented as

Reaction Equilibrium constant

$A (g) \rightleftharpoons B (g) : K = ?$

$B (g) \rightleftharpoons C (g) : K_2 = 0.4$

$C (g) \rightleftharpoons A (g) : K_3 = 0.6$

If one mole of A is taken in a closed vessel of volume 1 litre, then

(A) [A] + [B] + [C] = 1 M at any time of the reactions

(B) Concentration of C is 4.1 M at the attainment equilibrium in all the reactions

(C) The value of K_1 is $\dfrac{1}{0.24}$

(D) None of these

17. Which statement(s) is/are correct

(A) A solution is prepared by addition of excess of $AgNO_3$ solution in KI solution. The charge likely to develop on colloidal particle is positive.

(B) The effect of pressure on physical adsorption is high if temperature is low.

(C) Ultracentrifugation process is used for preparation of lyophobic colloids.

(D) Gold number is the index for extent of gold plating done.

18. Select the correct statement(s)

(A) Physisorption is favored by low temperature

(B) Chemisorption is favored by very high temperature because the process is endothermic

(C) Chemisorption increases with increase in temperature owing to high activation energy

(D) Oxygen adsorbed by charcoal can be desorbed by lowering pressure and increasing temperature.

COMPREHENSION # 1 (FOR Q. 19, 20)

19. $2A_2 \rightleftharpoons A_4$ ..... (i) $\quad K_{P_1} = \dfrac{2}{81} atm^{-1}$

$A_2 + 2C \rightleftharpoons A_2C_2$ ..... (ii)

$A_2C_2 \rightleftharpoons 2AC$ ..... (iii)

A_2 and C are taken in 3 : 1 mole ratio in a closed container of a certain volume at a fixed temperature and above three equilibriums are established simultaneously. KP_1 for the first reaction is $\dfrac{2}{81} atm^{-1}$. At equilibrium partial pressure of $A_4(g)$ and $AC(g)$ are found to be ½ atm each and the total pressure at equilibrium is found to be $\dfrac{27}{4}$ atm. Then, the partial pressure of A_2C_2 at equilibrium is

(A) 1/2   (B) 3/4   (C) 1/4   (D) 1

20. The mole ratio of gases A_2 and AC at equiliburm is

(A) 9/2   (B) 7/2   (C) 8   (D) 9

COMPREHENSION (FOR Q. 21, 22, 23)

Equilibrium constants are given (in atm) for the following reactions at 0° C:

$SnCl_2 . 6H_2O(s) \rightleftharpoons SnCl_2 . 2H_2O(s) + 4H_2O(g)$	$K_p = 5 \times 10^{-12}$
$Na_2HPO_4. 12H_2O(s) \rightleftharpoons Na_2HPO_4. 7H_2O(s) + 5H_2O(g)$	$K_p = 2.43 \times 10^{-13}$
$Na_2SO_4. 10H_2O(s) \rightleftharpoons Na_2SO_4(s) + 10H_2O (g)$	$K_p = 1.024 \times 10^{-27}$

The vapor pressure of water at 0°C is 4.56 torr.

21. Which is the most effective drying agent at 0°C?

(A) $SnCl_2. 2H_2O$ (B) $Na_2HPO_4. 7H_2O$ (C) Na_2SO_4 (D) all equally

22. At what relative humidity will $Na_2SO_4. 10H_2O$ be efflorescent (release moisture) when exposed to air at 0°C?

(A) above 33.33%   (B) below 33.33 %   (C) above 66.66%   (D) below 66.66%

23. At what relative humidity will Na_2SO_4 be deliquescent (absorb moisture) when exposed to the air at 0°C?

(A) above 33.33%   (B) below 33.33 %   (C) above 66.66%   (D) below 66.66%

24. Column-I and Column-II contains four entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II

Column-I	Column-II
(a) Chemisorption	(P) Not specific and decreases with temperature
(b) Physisorption	(Q) Specific and increases with temperature
(c) Desorption of a solute on liquid surface	(R) Increases the srurface tension of the liuqid
(d) Adsorption of a solute surface liquid liquid	(S) Decreases the surface tension of the on a

(A) a → Q; b → P; c → R; d → S

(B) a → P; b → Q; c → R; d → S

(C) a → P; b → Q; c → S; d → R

(D) a → Q; b → P; c → S; d → R

SUBJECTIVE QUESTIONS

25. In a vessel, two equilibrium are simultaneously established at the same temperature as follows:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ......(1)

$N_2(g) + 2H_2(g) \rightleftharpoons N_2H_4(g)$ ....(2)
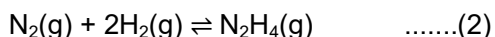
Initially the vessel contains N_2 and H_2 in the molar ratio of 9 : 13. The equilibrium pressure is $7P_0$, in which pressure due to ammonia is P0 and due to hydrogen is $2P_0$. Find the values of equilibrium constants (KP's) for both the reactions

26. 0.15 mole of CO taken in a 2.5 litre flask is maintained at 750 K along with a catalyst so that the following reaction can take place:

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

Hydrogen is introduced untill the total pressure of the system is 8.5 atm at equilibrium and 0.08 mole of methanol is formed. Calculate :

(i) K_p & K_c

(ii) the final pressure if the same amount of CO and H_2 as before are used, but with no catalyst so that the reaction does not take place.

27. A saturated solution of iodine in water contains 0.33 g I_2/L. More than this can dissolve in a KI solution because of the equilibrium:

$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$

A 0.10 M KI solution (0.10 M I^-) dissolves 12.5 g of iodine/L, most of which is converted to $I3^-$. Assuming that the concentration of I_2 in all saturated solutions is the same, calculate the equilibrium constant for the above reaction. What is the effect of adding water to a clear saturated of I_2 in the KI solution?

(A) 1   (B) 1   (C) 1   (D) 1

28. Which out of 'He' and 'Ne' would adsorb on the surface of charcoal more readily and why?