12

Surface Chemistry

TOPIC 1
Adsorption and Various Isotherms

01 CH_4 is adsorbed on 1 g charcoal at $0°C$ following the Freundlich adsorption isotherm. 10.0 mL of CH_4 is adsorbed at 100 mm of Hg, whereas 15.0 mL is adsorbed at 200 mm of Hg. The volume of CH_4 adsorbed at 300 mm of Hg is 10^x mL. The value of x is .... $\times 10^{-2}$. (Nearest integer)

[Use $\log_{10} 2 = 0.3010$, $\log_{10} 3 = 0.4771$] **[2021, 31 Aug Shift-II]**

Ans. ***(128)***

According to Freundlich isotherm,

$$\frac{x}{m} = kp^{\frac{1}{n}}$$

(Using, amount of adsorbate $\propto$ Volume of absorbate)

$$\frac{10}{1} = k \times (100)^{\frac{1}{n}} \quad \text{...(i)}$$

$$\frac{15}{1} = k \times (200)^{\frac{1}{n}} \quad \text{...(ii)}$$

$$\frac{v}{1} = k \times (300)^{\frac{1}{n}} \quad \text{...(iii)}$$

Divide Eq. (ii) by (i)

$$\frac{15}{10} = 2^{\frac{1}{x}} \Rightarrow \log\left(\frac{3}{2}\right) = \frac{1}{n} \log 2$$

$$\frac{1}{n} = \frac{\log 3 - \log 2}{\log 2} = \frac{0.4771 - 0.3010}{0.3010}$$

$$\frac{1}{n} = 0.585$$

Divide Eq. (iii) by (i)

$$\frac{v}{10} = 3^{\frac{1}{n}}$$

$$\log\left(\frac{v}{10}\right) = \frac{1}{n} \log 3$$

$$\log\left(\frac{v}{10}\right) = 0.585 \times 0.4771 = 0.2791$$

$$\frac{v}{10} = 10^{0.2791}$$

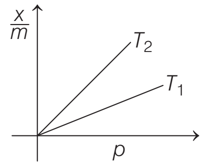
$$\Rightarrow \quad v = 10 \times 10^{0.2791}$$

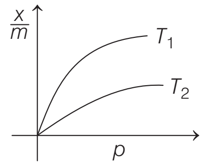
$$= 10^{1.279} = 10^x$$

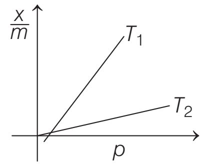
$$x = 1.279$$

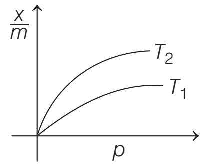
$$x = 128 \times 10^{-2}$$

02 Select the graph that correctly describes the adsorption isotherms at two temperatures T_1 and T_2 ($T_1 > T_2$) for a gas.
(x = mass of the gas adsorbed ;
m = mass of adsorbent ;
p = pressure) **[2021, 31 Aug Shift-I]**

(a)


(b)


(c)


(d)


Ans. ***(d)***

The graph that correctly describes the absorption isotherms at two temperature T_1 and T_2 is given by option (d).
According to Freundlich's adsorption isotherm, the amount of the gas adsorbed is directly proportional to pressure applied raised to the power $\frac{1}{n}$.

$$\frac{x}{m} \propto p^{\frac{1}{n}} \qquad \left[0 < \frac{1}{n} < 1\right]$$

So, on increasing temperature, $\frac{x}{m}$ decreases.

$\therefore$ Adsorption is basically exothermic in nature. Hence, correct option is (d).

03 Given below are two statement : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) $SO_2(g)$ is adsorbed to a large extent than $H_2(g)$ on activated charcoal.

Reason (R) $SO_2(g)$ has a higher critical temperature than $H_2(g)$.

In the light of the above statements, choose the most appropriate answer from the options given below.

[2021, 27 July Shift-II]

(a) Both A and R are correct but R is not the correct explanation of A
(b) Both A and R are correct and R is the correct explanation of A.
(c) A is not correct but R is correct.
(d) A is correct but R is not correct.

Ans. ***(b)***

As intermolecular force of attraction increases, critical temperature increases. with increase in critical temperature, extent of adsorption also increases. As SO_2 has more critical temperature than H_2, it is adsorbed to a larger extent on charcoal.

∴ Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.

04 CO_2 gas adsorbs on charcoal following Freundlich adsorption isotherm. For a given amount of charcoal, the mass of CO_2 adsorbed becomes 64 times when the pressure of CO_2 is doubled. The value of n in the Freundlich isotherm equation is ...... $\times 10^{-2}$. (Round off to the nearest integer)
[2021, 27 July Shift-I]

Ans. ***(17)***

According to Freundlich adsorption isotherm,

$$\frac{x}{m} = kp^{1/n}.$$

where x, m, k, p and n are amount of adsorbate, amount of adsorbent, pressure of gas and constant respectively.

For a given amount of charcoal, $x \propto p^{1/n}$

$$\frac{x_2}{x_1} = \left(\frac{p_2}{p_1}\right)^{1/n}$$

Therefore, $64 = (2)^{1/n}$

$2^6 = 2^{1/n}$

$6 = \frac{1}{n}$

$\Rightarrow$ $n = 0.166 = 0.17$

$n = 17 \times 10^{-2}$

05 Which one of the following is correct for the adsorption of a gas at a given temperature on a solid surface? **[2021, 26 Aug Shift-I]**

(a) $\Delta H > 0, \Delta S > 0$ (b) $\Delta H > 0, \Delta S < 0$
(c) $\Delta H < 0, \Delta S < 0$ (d) $\Delta H < 0, \Delta S > 0$

Ans. ***(c)***

The ΔH (enthalpy change) and ΔS (entropy change) will be less than zero for adsorption of gas on solid surface, i.e. $\Delta H < 0$, $\Delta S < 0$.

Entropy change (ΔS) The randomness of the gas molecules decreases as they are adsorb on solid surface due to restriction in their motion.

∴ ΔS is negative.

Enthalpy change (ΔH) Adsorption of gas on solid surface is an exothermic process, as there is force of attraction between adsorbate and adsorbent.

∴ ΔH is negative.

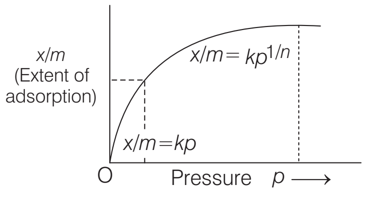
06 In Freundlich adsorption isotherm at moderate pressure, the extent of adsorption $\left(\frac{x}{m}\right)$ is directly proportional to p^x. The value of x is
[2021, 25 Feb Shift-I]

(a) 1 (b) zero (c) ∞ (d) $\frac{1}{n}$

Ans. ***(d)***

According to Freundlich isotherm, at moderate pressure, extent of adsorption

$$\left(\frac{x}{m}\right) \propto (p)^{\frac{1}{n}}$$



At moderate pressure,

$$\frac{x}{m} = k(p)^{1/n}$$

$$\frac{x}{m} \propto (p)^{1/n} \quad \text{...(i)}$$

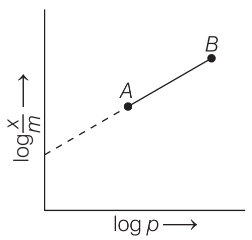
$$\frac{x}{m} \propto p^x \quad \text{(Given inquestion) ... (ii)}$$

Compare Eqs. (i) and (ii),

$(p)^{1/n} \propto p^x$

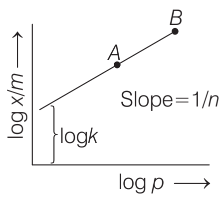
∴ $x = \frac{1}{n}$

07 In Freundlich adsorption isotherm, slope of AB line is
[2021, 24 Feb Shift-I]



(a) n with ($n = 0.1$ to 0.5)
(b) $\log n$ with ($n > 1$)
(c) $\log \frac{1}{n}$ with ($n < 1$)
(d) $\frac{1}{n}$ with $\left(\frac{1}{n} = 0 \text{ to } 1\right)$

Ans. ***(d)***



Given graph is Freundlich adsorption isotherm.

According to equation,

$$\frac{x}{m} = kp^{\frac{1}{n}} \quad \text{...(i)}$$

where, $\frac{x}{m}$ = amount of gas

k and n = constants depending upon nature of adsorbate and absorbent.

Now, taking log both side in Eq. (i), we get

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log p$$

For straight line, comparing above equation to $y = mx + c$

So, $m = \text{slope} = \frac{1}{n}$

hence, $0 \le \frac{1}{n} \le 1$

It value lies in between 0 to 1.

Hence, $\frac{1}{n}$ with $\left(\frac{1}{n} = 0 \text{ to } 1\right)$.

08 Amongst the following statements regarding adsorption, those that are valid are: **[2020, 2 Sep Shift-II]**

(A) ΔH becomes less negative as adsorption proceeds.
(B) On a given adsorbent, ammonia is adsorbed more than nitrogen gas.
(C) On adsorption, the residual force acting along the surface of the adsorbent increases.
(D) With increase in temperature, the equilibrium concentration of adsorbate increases.

(a) (D) and (A) (b) (B) and (C)
(c) (A) and (B) (d) (C) and (D)

Ans. ***(c)***

On adsorption (both physical and chemical), the residual force acting along the surface of absorbent decreases. So, ΔH of the adsorption becomes less negative as adsorption proceeds. So, statement (a) is correct but statement (c) is incorrect. Ammonia molecules (NH_3) is larger in size and dipolar in nature. Nitrogen is smaller in size and it is a non-polar molecule. So, degree of adsorption : $NH_3 > N_2$. So, statement (b) is correct. With increase in temperature, kinetic energy of adsorbate molecules will increase and hence, its equilibrium concentration will decrease.

So, statement (d) is not correct.

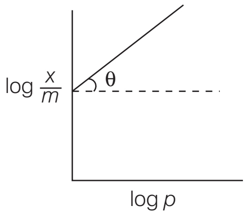
09 The mass of gas adsorbed, x per unit mass of adsorbate, m was measured at various pressures, p. A graph between $\log \frac{x}{m}$ and $\log p$ gives a straight line with slope equal to 2 and the intercept equal to 0.4771. The value of $\frac{x}{m}$ at a pressure of 4 atm is
(Given, log 3 = 0.4771)

[2020, 2 Sep Shift-I]

Ans. ***(6)***

From Freundlich adsorption isotherm equation,

$$\log \frac{x}{m} = \log K + \frac{1}{n} \log p$$



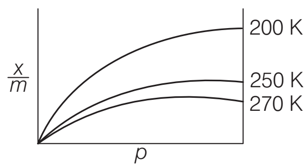
When we plot $\log x/m$ vs $\log p$, we get a straight line of

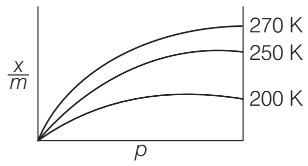
(i) slope $= \frac{1}{n} = 2 \Rightarrow n = \frac{1}{2}$

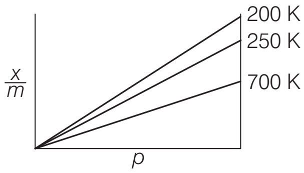
(ii) intercept $= \log K = 0.4771$
$\Rightarrow \log K = \log 3$
$\Rightarrow \quad K = 3$
So, $\frac{x}{m} = Kp^{1/n} = 3 \times 4^2$
$= 48.00 \quad (\because p = 4 \text{ atm})$

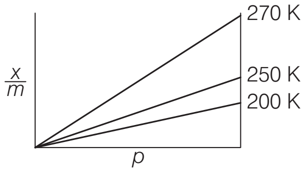
10 Adsorption of a gas follows Freundlich adsorption isotherm. If x is the mass of the gas adsorbed on mass m of the adsorbent, the correct plot of $\frac{x}{m}$ *versus* p is

[2020, 5 Sep Shift-II]

(a)


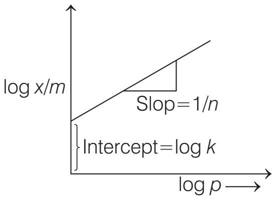
(b)


(c)


(d)


Ans. ***(a)***

Freundlich adsorption gives the variation in the quantity of gas adsorbed by a unit mass of solid adsorbent with the change in pressure of the system for a given temperature.



The expression for the Freundlich isotherm can be represented by the following equation.

$$\frac{x}{m} = kp^{1/n}$$

where, $n > 1$

where, x is the mass of gas adsorbed, x is the mass of adsorbent. p is pressure and n is a constant, which depends upon the nature of adsorbent and the gas at a given temperature.

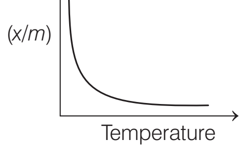
Taking the logarithm on both side of the equation,

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log p$$

$\frac{x}{m} \propto p$ (At low pressure)

$\frac{x}{m} \propto p^{\circ}$ (At high pressure)

On increasing temperature physical adsorption decreases



Hence, option (a) is correct.

11 For Freundlich adsorption isotherm, a plot of $\log\left(\frac{x}{m}\right)$ (y-axis) and $\log p$ (x-axis) gives a straight line. The intercept and slope for the line is 0.4771 and 2, respectively. The mass of gas, adsorbed per gram of adsorbent if the initial pressure is 0.04 atm, is .... $\times 10^{-4}$ g. ($\log 3 = 0.4771$)

[2020, 6 Sep Shift-II]

Ans. ***(48)***

According to Freundlich adsorption isotherm

$$\frac{x}{m} = Kp^{1/n} \quad \text{...(i)}$$

Taking logarithm of Eq. (i)

$$\log \frac{x}{m} = \log K + \frac{1}{n} \log p \quad \text{...(ii)}$$

Here, given slope $= \frac{1}{n} = 2$,

pressure $(p) = 0.04$ atm and intercept
$= \log K = 0.4771 \quad (\therefore K = 3)$

mass of gas adsorbed per gram of adsorbent

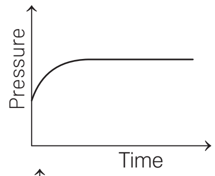
$$= \frac{x}{m} = K \cdot p^{1/n}$$

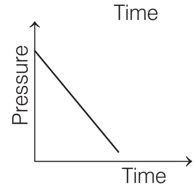
$$\frac{x}{m} = 3 \cdot p^2$$

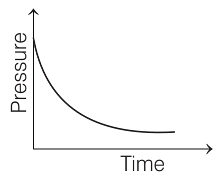
$$\Rightarrow \quad \frac{x}{m} = 3 \times (0.04)^2 = 48 \times 10^{-4}.$$

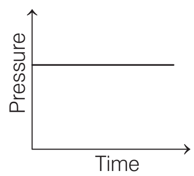
12 A mixture of gases O_2, H_2 and CO are taken in a closed vessel containing charcoal. The graph that represents the correct behaviour of pressure with time is

[2020, 9 Jan Shift-II]

(a)


(b)


(c)


(d)


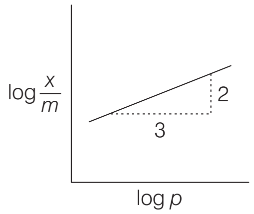
Ans. ***(c)***

Option (c) is the graph that represents correct behaviour of pressure with time. With passage of time, the pressure of the gases decreases and finally reach a constant value.

It is due to adsorption of gases by charcoal. The decrease in pressure is faster in the beginning, but as the adsorbent charcoal gets saturated, pressure attains constancy.

13 Adsorption of a gas follows Freundlich adsorption isotherm. x is the mass of the gas adsorbed on mass m of the adsorbent. The plot of $\log\frac{x}{m}$ *versus* $\log p$ is shown in the given graph. $\frac{x}{m}$ is proportional to

[2019, 8 April Shift-I]



(a) $p^{2/3}$ (b) $p^{3/2}$
(c) p^3 (d) p^2

Ans. ***(a)***

Key Idea According to Freundlich,

$$\frac{x}{m}=kp^{1/n}\ [n>1]$$

where, m = mass of adsorbent, x = mass of the gas adsorbed, $\frac{x}{m}$ = amount of gas adsorbed per unit mass of solid adsorbent,
p = pressure, K and n = constants.

The logarithm equation of Freundlich adsorption isotherm is

$$\log\frac{x}{m}=\log K+\frac{1}{n}\log p$$

On comparing the above equation with straight line equation, $(y=mx+c)$

we get $m=\text{slope}=\frac{1}{n}$ and $c=\log K$

From the given plot,

$$m=\frac{y_2-y_1}{x_2-x_1}$$

$$=\frac{1}{n}=\frac{2}{3}$$

$$\Rightarrow \quad \frac{x}{m}=Kp^{2/3}$$

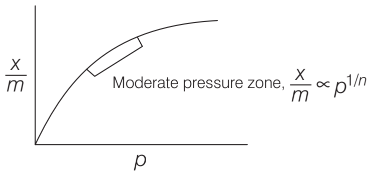
14 A gas undergoes physical adsorption on a surface and follows the given Freundlich adsorption isotherm equation $\frac{x}{m}=Kp^{0.5}$

Adsorption of the gas increases with **[2019, 10 April Shift-I]**

(a) increase in p and increase in T
(b) increase in p and decrease in T
(c) decrease in p and decrease in T
(d) decrease in p and increase in T

Ans. ***(b)***

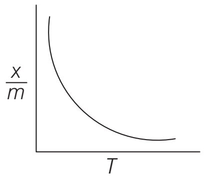
For physisorption or physical adsorption, Adsorption isotherm (Temperature, T = constant) is shown below:



where, x = amount of adsorbate,
m = amount of adsorbent,
$\frac{x}{m}$ = degree of adsorption
$\frac{1}{n}$ = order of the reaction, where, $0<\frac{1}{n}<1$
and so, $1<n<\infty$

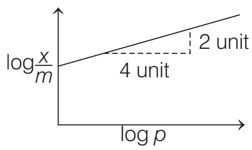
Here, $\frac{x}{m}=Kp^{\frac{1}{2}}$, i.e. $\frac{x}{m}\propto p^{\frac{1}{2}}$

Adsorption isobar (Pressure, p = constant)



So, the rate of physical adsorption of the gas, increases with p (when, T is constant) and decreases with T (when p is constant).

15 Adsorption of a gas follows Freundlich adsorption isotherm. In the given plot, x is the mass of the gas adsorbed on mass m of the adsorbent at pressure $p\cdot(x/m)$ is proportional to



(a) p^2 (b) $p^{1/4}$ (c) $p^{1/2}$ (d) p

[2019, 9 Jan Shift-I]

Ans. ***(c)***

According to Freundlich adsorption isotherm,

$$\frac{x}{m}\propto p^{\frac{1}{n}} \Rightarrow \frac{x}{m}=Kp^{1/n}$$

On taking log on both sides, we get

$$\log\left(\frac{x}{m}\right)=\log K+\frac{1}{n}\log p$$

On comparing with equation of straight line, $y=mx+c$, plot of $\log\frac{x}{m}$ vs $\log p$ gives,

Slope $\frac{(y_2-y_1)}{(x_2-x_1)}=\frac{1}{n}\Rightarrow\frac{2}{4}=\frac{1}{2}$

$$\Rightarrow \quad \frac{x}{m}\propto p^{1/2}$$

16 The correct match between item-I and Item-II is

A. Benzaldehyde
P. Dynamic phase
B. Alumina
Q. Adsorbent
C. Acetonitrile
R. Adsorbate **[2019, 9 Jan Shift-II]**

(a) (A)→(R); (B)→(Q); (C)→(P)
(b) (A)→(P); (B)→(R); (C)→(Q)
(c) (A)→(Q); (B)→(P); (C)→(R)
(d) (A)→(Q); (B)→(R); (C)→(P)

Ans. ***(a)***

Using the principle of adsorption chromatography, qualitative and quantitative analysis of benzaldehyde can be done from its mixture with acetonitrile. Here, a mobile phase moves over a stationary phase (adsorbent). Adsorbents used are alumina (Al_2O_3) and silica gel. The sample solution of benzaldehyde and acetonitrile when comes in contact with the adsorbent, benzaldehyde gets adsorbed on the surface of the adsorbent. So, benzaldehyde acts as absorbate whereas acetonitrile starts moving as mobile phase over the stationary phase of the adsorbate. Hence, act as dynamic phase.

17 Given,

Gas :	H_2,	CH_4,	CO_2,	SO_2
Critical temp./K	33	190	304	630

On the basis of data given above, predict which of the following gases shows least adsorption on a definite amount of charcoal?

(a) CH_4 (b) SO_2 (c) CO_2 (d) H_2

[2019, 12 Jan Shift-I]

Ans. ***(d)***

Same adsorbant (charcoal in this case) at same temperature will adsorb different gases to different extent. The extent to which gases are adsorbed is proportional to the critical temperature of gas.

$$\because \qquad T_c = \frac{8a}{27Rb}$$

where, a is the magnitude of intermolecular forces between gaseous molecules.

Thus, higher the cirtical temperature more is the gas adsorbed. Among the given gases, H_2 has the minimum critical temperature, i.e. 33K thus, it shows least adsorption on a definite amount of charcoal.

18 For a linear plot of $\log(x/m)$ *versus* $\log p$ in a Freundlich adsorption isotherm, which of the following statements is correct? (k and n are constants) **[JEE Main 2016]**

(a) $1/n$ appears as the intercept

(b) Only $1/n$ appears as the slope

(c) $\log\left(\frac{1}{n}\right)$ appears as the intercept

(d) Both k and $1/n$ appear in the slope term

Ans. ***(b)***

According to Freundlich adsorption isotherm,

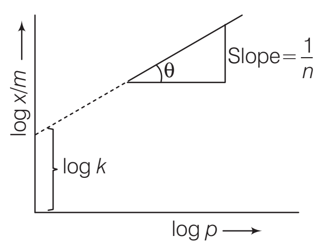
$$\frac{x}{m} = kp^{1/n}$$

On taking logarithm of both sides, we get

$$\log \frac{x}{m} = \log k + \log p^{1/n}$$

or $$\log \frac{x}{m} = \log k + \frac{1}{n}\log p$$

$$y = c + mx$$



$$y = \log \frac{x}{m},\ c = \text{intercept} = \log k,$$

$$m = \text{slope} = \frac{1}{n}$$

and $\quad x = \log p$

19 According to Freundlich adsorption isotherm which of the following is correct? **[AIEEE 2012]**

(a) $\frac{x}{m} \propto p^0$

(b) $\frac{x}{m} \propto p^1$

(c) $\frac{x}{m} \propto p^{1/n}$

(d) All of the above are correct for different range of pressure

Ans. ***(d)***

By Freundlich adsorption isotherm

$$\frac{x}{m} = kp^{1/n}$$

[In between low and high pressure range]

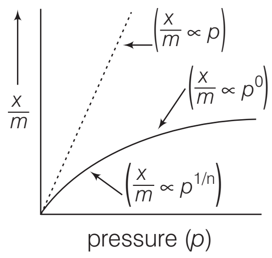
When $n = 1$,

$$\frac{x}{m} \propto p^1$$

[In low pressure range]

When n is large, $\frac{x}{m} = k$

[Independent of pressure]



Thus, $$\frac{x}{m} \propto p^0$$

[At high pressure range when saturation point is reached]

20 Which of the following statements is incorrect regarding physisorptions? **[AIEEE 2009]**

(a) It occurs because of van der Waals' forces

(b) More easily liquefiable gases are adsorbed readily

(c) Under high pressure, it results into multi molecular layer on adsorbent surface

(d) Enthalpy of adsorption ($\Delta H_{\text{adsorption}}$) is slow and positive

Ans. ***(d)***

Adsorption is an exothermic process *i.e.*, energy is released against van der Waals' force of attraction (physisorptions).

Hence, ΔH is always negative.

21 In Langmuir's model of adsorption of a gas on a solid surface **[AIEEE 2006]**

(a) the rate of dissociation of adsorbed molecules from the surface does not depend on the surface covered

(b) the adsorption at a single site on the surface may involve multiple molecules at the same time

(c) the mass of gas striking a given area of surface is proportional to the pressure of the gas

(d) the mass of gas striking a given area of surface is independent of the pressure of the gas

Ans. ***(c)***

The adsorption of a gas is directly proportional to the pressure of the gas.

22 Which one of the following characteristics is not correct for physical adsorption? **[AIEEE 2003]**

(a) Adsorption on solids is reversible

(b) Adsorption increases with increase in temperature

(c) Adsorption is spontaneous

(d) Both enthalpy and entropy of adsorption are negative

Ans. ***(b)***

As temperature increases desorption increases. Adsorbent + Adsorbate $\rightleftharpoons$ Adsorbed state + ΔE

Adsorption is exothermic process (forward direction), desorption is endothermic process (backward direction).

According to Le-Chatelier's principle, increase in temperature favours endothermic process.

TOPIC 2
Catalyst

23 Which one of the following statements is not true about enzymes ? **[2021, 20 July Shift-II]**

(a) Enzymes are non-specific for a reaction and substrate.

(b) Almost all enzymes are proteins.

(c) Enzymes work as catalysts by lowering the activation energy of a biochemical reaction.

(d) The action of enzymes is temperature and pH specific.

Ans. ***(a)***

Statement (a) is not true whereas all other statements are true.

An enzyme is a substance that acts as a catalyst in living organism, regulating rate at which chemical reaction proceed without itself being altered in the process.

The biological processes that occur within all living organisms are chemical reaction and most are regulated by enzymes. Enzymes are highly specific in nature.

24 Match List-I with List-II.

List-I (Process)		List-II (Catalyst)	
(A)	Deacon's process	(i)	ZSM-5
(B)	Contact process	(ii)	$CuCl_2$
(C)	Cracking of hydrocarbons	(iii)	Particles 'Ni'
(D)	Hydrogenation of vegetable oils	(iv)	V_2O_5

Choose the most appropriate answer from the options given below **[2021, 18 March Shift-I]**

	A	B	C	D		A	B	C	D
(a)	(ii)	(iv)	(i)	(iii)	(b)	(i)	(iii)	(ii)	(iv)
(c)	(iii)	(i)	(iv)	(ii)	(d)	(iv)	(ii)	(i)	(iii)

Ans. ***(a)***

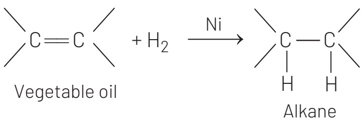
A. Deacon's process is used for industrial preparation of chlorine gas.

$$HCl + [O_2] \xrightarrow[723\,K]{CuCl_2} H_2O + Cl_2$$

B. Contact process is used for industrial preparation of sulphuric acid where V_2O_5 as a catalyst involved in the process.

C. ZSM-5 used as catalyst in cracking of hydrocarbons.

D. Ni catalysts enables the hydrogenation of fats.



∴ Correct match is (A-ii), (B-iv), (C-i), (D-iii).

25 For the following Assertion and Reason the correct option is

Assertion For hydrogenation reactions, the catalytic activity increases from Group 5 to Group 11 metals with maximum activity shown by Group 7-9 elements.

Reason The reactants are most strongly adsorbed on group 7-9 elements. **[2020, 8 Jan Shift-II]**

(a) The Assertion is true, but the Reason is false.

(b) Both Assertion and Reason are true, but the Reason is not the correct explanation for the Assertion.

(c) Both Assertion and Reason are true and the Reason is the correct explanation for the Assertion.

(d) Both Assertion and Reason are false.

Ans. ***(a)***

Assertion is correct but Reason is incorrect. Correct reason is as follows: To show maximum catalytic activity, reactants must be adsorbed on to the surface of catalysis reasonably strong but not too strong to become immobilised. So, most catalytic activity corresponds to a moderately strong adsorption, not extremely strong adsorption.

26 Match the catalysts Column I with products Column II.

Column I (Catalyst)		Column II (Product)	
(A)	V_2O_5	(i)	Polyethlyene
(B)	$TiCl_4$ / $Al(Me)_3$	(ii)	Ethanal
(C)	$PbCl_2$	(iii)	H_2SO_4
(D)	Iron oxide	(iv)	NH_3

[2019, 9 April Shift-I]

(a) (A)-(ii), (B)-(iii), (C)-(i), (D)-(iv)

(b) (A)-(iv), (B)-(iii), (C)-(ii), (D)-(i)

(c) (A)-(iii), (B)-(i), (C)-(ii), (D)-(iv)

(d) (A)-(iii), (B)-(iv), (C)-(i), (D)-(ii)

Ans. ***(c)***

Correct match is

(A)→(iii); (B)→(i); (C)→(ii); (D)→(iv)

(i) $TiCl_4 + AlCl_3$ (*Ziegler- Natta* catalyst) is used to prepare polyethylene from ethene.

(ii) V_2O_5 (Vanadium pentoxide) is used as catalyst to prepare H_2SO_4 from contact process. Reaction involved is

$$2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$$

It is the key step in the manufacture of H_2SO_4.

(iii) Fe (Iron) is used as catalyst in Haber's process for the manufacture of ammonia.

$$N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$$

(iv) Pd (Palladium) is used to prepare ethanal. Reaction involved is

$$H_2C{=\!=}CH_2 + O_2 \xrightarrow[H_2O]{PdCl_2 / CuCl_2} CH_3CHO$$

This reaction is also known as Wacker's process.

27 Which of the following is not an example of heterogeneous catalytic reaction?

(a) Haber's process

(b) Combustion of coal

(c) Hydrogenation of vegetable oils

(d) Ostwald's process

[2019, 10 Jan Shift-I]

Ans. ***(b)***

In heterogeneous catalytic reactions, physical state of reactants and that of catalyst(s) used are different.

Haber's process, hydrogenation of vegetable oils and Ostwald's process all are heterogeneous process. Combustion of coal is not a heterogeneous catalytic reaction.

In Haber's process

$$N_2(g) + 3H_2(g) \xrightarrow{Fe(s),\ Mo(s)} 2NH_3(g)$$

Hydrogenation of vegetable oils,

$$\underset{\text{(Unsaturated)}}{\text{Vegetable oil}(l)} \xrightarrow[\text{or Ni}(s)]{[(Ph_3P)_3Rh]Cl} \text{Vanaspat}(s)$$

Ostwald's process,

$$4NH_3(g) + 5O_2(g) \xrightarrow[V_2O_5(s)]{Pt(s)} 4NO(g) + 6H_2O(g)$$

No catalyst is used in combustion of coal. The reaction is highly spontaneous in nature.

$$\underset{\text{(Coal)}}{C} + O_2 \longrightarrow CO_2$$

28 Match the catalysts to the correct processes. **[JEE Main 2015]**

Catalyst		Process	
(A)	$TiCl_3$	(i)	Wacker process
(B)	$PdCl_2$	(ii)	Ziegler- Natta polymerisation
(C)	$CuCl_2$	(iii)	Contact process
(D)	V_2O_5	(iv)	Deacon's process

(a) (A)-(iii), (B)-(ii), (C)-(iv), (D)-(i)
(b) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii)
(c) (A)-(ii), (B)-(iii), (C)-(iv), (D)-(i)
(d) (A)-(iii), (B)-(i), (C)-(ii), (D)-(iv)

Ans. ***(b)***

(a) $TiCl_3$ is used as Ziegler-Natta catalyst for the polymerisation of ethene.

(b) $PdCl_2$ is used in Wacker process, in which alkene changed into aldehyde *via* catalytic cyclic process initiated by $PdCl_2$.

(c) $CuCl_2$ is used in Deacon's process. (for Cl_2)

(d) V_2O_5 is used in contact process of manufacturing sulphuric acid.

Time Saving Technique This type of questions can also be solved through elimination technique. There is no need to know all the four matches to select the correct response. Even if you know (b) matches then also you can solve the problem. e.g. suppose you know the usage of V_2O_5 in contact process (i.e. D matches with (iii) and $TiCl_3$ is connected to Ziegler-Natta catalyst (i.e. A matches with ii).

These two combinations are present only in option number (b). Likewise, for this question particularly if you know that V_2O_5 is used in contact process then this combination is present in option (b) only out of all the four option given. In this way you can eliminate wrong options to get the correct response.

TOPIC 3
Colloids, Micelles and Emulsions

29 Match List-I with List-II.

List-I (Colloid preparation method)	List-II (Chemical reaction)
A. Hydrolysis	1. $2AuCl_3 + 3HCHO + 3H_2O \rightarrow 2Au(sol) + 3HCOOH + 6HCl$
B. Reduction	2. $As_2O_3 + 3H_2S \rightarrow As_2S_3(sol) + 3H_2O$
C. Oxidation	3. $SO_2 + 2H_2S \rightarrow 3S(sol) + 2H_2O$
D. Double Decomposition	4. $FeCl_3 + 3H_2O \rightarrow Fe(OH)_3(sol) + 3HCl$

Choose the most appropriate answer from the options given below. **[2021, 1 Sep Shift-II]**

	A	B	C	D		A	B	C	D
(a)	1	3	2	4	(b)	4	1	3	2
(c)	4	2	3	1	(d)	1	2	4	3

Ans. ***(b)***

According to type of reaction for colloid preparation, colloids have been classified.

A. Hydrolysis —
$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3(sol) + 3HCl$

B. Reduction—
$2AuCl_3 + 3HCHO + 3H_2O \longrightarrow 2Au(sol) + 3HCOOH + 6HCl$

C. Oxidation— $SO_2 + 2H_2S \longrightarrow 3S(sol) + 2H_2O$

D. Double decomposition—
$As_2O_3 + 3H_2S \longrightarrow As_2S_3(sol) + 3H_2O$

Hence, the correct match is
$A \rightarrow 4, B \rightarrow 1, C \rightarrow 3, D \rightarrow 2.$

30 Lyophilic sols are more stable than lyophobic sols because **[2021, 27 Aug Shift-II]**

(a) there is a strong electrostatic repulsion between the negatively charged colloidal particles.
(b) the colloidal particles have positive charge.
(c) the colloidal particles have no charge.
(d) the colloidal particles are solvated.

Ans. ***(d)***

Lyophilic sols are more stable than lyophobic sols. Lyophilic sols are solvent loving, whereas lyophobic sols are solvent hating. The dispersed phase in lyophobic sols has no attraction for the solvent. The dispersed phase in lyophilic sols has attraction for the solvent. The colloidal particles are solvated in the dispersed medium and therefore stabilised through solvation process. Therefore, the option (d) is correct.

31 The conditions given below are in the context of observing Tyndall effect in colloidal solutions

(A) The diameter of the colloidal particles is comparable to the wavelength of light used.
(B) The diameter of the colloidal particles is much smaller than the wavelength of light used.
(C) The diameter of the colloidal particles is much larger than the wavelength of light used.
(D) The refractive indices of the dispersed phase and the dispersion medium are comparable.
(E) The dispersed phase has a very different refractive index from the dispersion medium.

Choose the most appropriate conditions from the options given below. **[2021, 20 July Shift-I]**

(a) (A) and (E) only
(b) (C) and (D) only
(c) (A) and (D) only
(d) (B) and (E) only

Ans. ***(a)***

Option (*A*) and (*E*) are the conditions for showing Tyndall effect in colloidal solution.

The phenomenon of scattering of light by colloidal particles as a result of which the path of the beam becomes visible is called a Tyndall effect. Smaller the diameter and similar the magnitude of refractive indices, lesser is the scattering and hence the Tyndall effect. The diameter of the dispersed phase particle should not be smaller than the wavelength of light used because they won't be able to scatter the light so, therefore, the diameter of the dispersed particles should be equal or not much smaller than the wavelength of the light used.

In option (D), the refractive index (i.e. the ratio of the velocity of light in vacuum to the velocity of light in any medium) of the dispersed phase and the dispersion medium should differ greatly in magnitude then only the particles will be able to scatter the light and Tyndall effect will be observed.

Hence, option (a) is correct.

32 Tyndall effect is more effectively shown by **[2021, 27 Aug Shift-I]**

(a) true solution
(b) lyophilic colloid
(c) lyophobic colloid
(d) suspension

Ans. ***(c)***

Tyndall effect is more effectively shown by lyophobic colloid because in lyophobic colloids, the particles are not as highly solvated as in lyophilic sols. So, the difference in refractive index between the particles and the medium is quite large in lyophobic colloids. Therefore, the tyndall effect is more pronounced in lyophobic sols or colloids.

33 The sol given below with negatively charged colloidal particles is **[2021, 26 Aug Shift-II]**

(a) $FeCl_3$ added to hot water
(b) KI added to $AgNO_3$ solution
(c) $AgNO_3$ added to KI solution
(d) $Al_2O_3 \cdot xH_2O$ in water

Ans. ***(c)***

- When $AgNO_3$ is added to KI,

$$KI \xrightarrow{AgNO_3} AgI\downarrow \xrightarrow{KI} \underset{\text{Negatively charged}}{AgI\ I^-}$$

Iodide ion gets adsorbed on the surface of AgI. This will result in formation of negatively charged colloids.

- When KI is added to $AgNO_3$ following reaction takes place.

$$AgNO_3 \xrightarrow{KI} AgI\downarrow \xrightarrow{AgNO_3} \underset{\text{Positively charged}}{AgI\ Ag^+}$$

Silver cation gets adsorbed on surface of AgI, resulting in formation of positively charged colloids.

- Option (a) and (d) will form positively charged colloids.

34 Match List I with List II.

	List I		List II
(A)	Cheese	I.	Dispersion of liquid in liquid
(B)	Pumice stone	II.	Dispersion of liquid in gas
(C)	Hair cream	III.	Dispersion of gas in solid
(D)	Cloud	IV.	Dispersion of liquid in solid

Choose the most appropriate answer from the options given below. **[2021, 25 July Shift-II]**

	A	B	C	D
(a)	IV	III	II	I
(b)	IV	I	III	II
(c)	III	IV	I	II
(d)	IV	III	I	II

Ans. ***(d)***

Dispersion of various system in which distributed particles of one material are dispersed in a continuous phase of another material. The two phases may be in the same or different state of matter.

Cheese → Dispersion of liquid in solid.

Pumice stone → Dispersion of gas in solid.

Hair cream → Dispersion of liquid in liquid.

Cloud → Dispersion of liquid in gas.

35 100 mL of 0.0018% (*w*/*v*) solution of Cl^- ion was the minimum concentration of Cl^- required to precipitate a negative sol in one h. The coagulating value of Cl^- ion is .... (Nearest integer) **[2021, 20 July Shift-II]**

Ans. ***(1)***

Coagulation value The minimum concentration of electrolyte in millimoles required to cause coagulation of 1 L of colloidal solution.

Given, 0.0018 g Cl^- present in 100 mL solution

Coagulation value of Cl^- is

$$= \frac{\frac{0.0018}{35.5} \times 10^3}{0.1} = 0.5070 \simeq 1$$

36 The charges on the colloidal CdS sol and TiO_2 sol are, respectively **[2021, 18 March Shift-II]**

(a) positive and positive
(b) positive and negative
(c) negative and negative
(d) negative and positive

Ans. ***(d)***

Oxides and hydroxide sol are positively charged.

So, TiO_2 is positive sol. Sulphide sol are negatively charge hence, CdS is negatively charge sol.

37 For the coagulation of a negative sol, the species below, that has the highest flocculating power is **[2021, 17 March Shift-II]**

(a) SO_4^{2-} (b) Ba^{2+}
(c) Na^+ (d) PO_4^{3-}

Ans. ***(b)***

To coagulate negative sol, Ba^{2+} cation has highest coagulation value.

For a negative sol, a positive ion is required for flocculation.

According to Hardy-Schulze law, greater the valence of the flocculating ion added, the greater is its power to cause precipitation.

38 A colloidal system consisting of a gas dispersed in a solid is called a/an **[2021 , 17 March Shift-I]**

(a) solid sol (b) gel
(c) aerosol (d) foam

Ans. ***(a)***

A colloidal system consisting of a gas (dispersed phase) dispersed in a solid (dispersed medium) is called a solid sol.

	DP	DM	Type of colloid
(a)	Gas	Solid	Solid sol
(b)	Liquid	Solid	Gel
(c)	Solid	Gas	Aerosol
(d)	Gas	Liquid	Foam

39 The nature of charge on resulting colloidal particles when $FeCl_3$ is added to excess of hot water is **[2021, 26 Feb Shift-II]**

(a) Positive
(b) Sometimes positive and sometimes negative
(c) Neutral
(d) Negative

Ans. ***(a)***

When $FeCl_3$ is added to excess of hot water,
a positively charged hydrated ferric oxide $[Fe_2O_3 \cdot xH_2O/Fe^{3+}]$ is formed due to adsorption Fe^{3+} ion (adsorbate) on the surface of hydrated ferric oxide (adsorbent).

$$FeCl_3 \xrightarrow[\Delta]{H_2O\,(\text{Excess})} \underset{\substack{\text{(Positively charged sol}\\ \text{or positive colloid)}}}{[Fe_2O_3 \cdot xH_2O] \cdot Fe^{3+}} + 3Cl^-(aq)$$

40 Which one of the following statements is false for hydrophilic sols ? **[2021, 25 Feb Shift-II]**

(a) They do not require electrolytes for stability.
(b) These sols are reversible in nature.
(c) Their viscosity is of the order of that of H_2O.
(d) The sols cannot be easily coagulated.

Ans. ***(c)***

Statement (c) is false whereas other statements are true. Corrected statement is as follows :

Viscosity of hydrophilic sols is higher than that of the dispersion medium, i.e. H_2O, because there is a high concentration of dispersed phase in water.

41 Most suitable salt which can be used for efficient clotting of blood will be **[2021, 24 Feb Shift-II]**

(a) $NaHCO_3$ (b) $FeSO_4$
(c) $Mg(HCO_3)_2$ (d) $FeCl_3$

Ans. ***(d)***

According to Hardy-Schulze rule, for negatively charged sol, most (+ve) charged ion is needed for efficient coagulation.

Blood is a negatively charged sol. Hence $FeCl_3$ can be used for blood clotting and it from Fe^{3+} ion.

42 Tyndall effect is observed when **[2020, 3 Sep Shift-I]**

(a) the diameter of dispersed particles is much larger than the wavelength of light used
(b) the diameter of dispersed particles is much smaller than the wavelength of light used
(c) the refractive index of dispersed phase is greater than that of the dispersion medium
(d) the diameter of dispersed particles is similar to the wavelength of light used

Ans. ***(d)***

Tyndall effect, an optical property, is observed by colloids, preferably lyophobic colloidal sols.

Here, visible light of wavelength range more than 400 nm scattered when they are incident on colloidal particles of sizes (diameter, 10^{-7} - 10^{-5} cm) commensurate with their wavelengths. In lyophobic colloids, refractive index of the dispersed phase is smaller than that of dispersion medium.

So, option (c) is also not correct.

43 Match the following:

I. Foam	(A) Smoke
II. Gel	(B) Cell fluid
III. Aerosol	(C) Jellies
IV. Emulsion	(D) Rubber
	(E) Froth
	(F) Milk

[2020, 4 Sep Shift-I]

(a) (I)-(D), (II)-(B), (III)-(A), (IV)-(E)
(b) (I)-(B), (II)-(C), (III)-(E), (IV)-(D)
(c) (I)-(E), (II)-(C), (III)-(A), (IV)-(F)
(d) (I)-(D), (II)-(B), (III)-(E), (IV)-(F)

Ans. ***(c)***

Correct match is (I) $\rightarrow$ E, (II) $\rightarrow$ C, (III) $\rightarrow$ A, (IV) $\rightarrow$ F

(I) Foam – Froth
Foam forms gas particles trapped in solid or liquid.

(II) Gel – Jellies
Gel is a colloid, where dispersed phase is liquid and dispersion medium is solid.

(III) Aerosol – Smoke
Aerosol is a colloid, where solid/liquid particles dispersed in gas.

(IV) Emulsion– Milk
Emulsion is formed by mixing two liquids. (Milk is combination of 2 liquid)

44 A sample of red ink (a colloidal suspension) is prepared by mixing eosin dye, egg white, HCHO and water. The component which ensures stability of the ink sample is **[2020, 4 Sep Shift-II]**

(a) egg white (b) eosin dye
(c) HCHO (d) water

Ans. ***(a)***

Egg white is a lyophilic colloid and for its stability lyophobic colloid is mixed in it. Because, egg white is a lyophilic colloid it is mixed with red ink sample for its stability. Hence, option (a) is correct.

45 Which of the following is used for the preparation of colloids? **[2020, 2 Sep Shift-I]**

(a) Bredig's Arc method
(b) Ostwald process
(c) Mond process
(d) van Arkel method

Ans. ***(a)***

Using Bredig's arc method, colloids (metal sols which are lyophobic) can be prepared.

In this method, two electrodes of metal (whose sol is to be prepared) are dipped in concentrated alkali. The electrodes act as arc for high voltage transmission of current. The metal particles get dispersed in the medium to produce metal sols like Au-sol, Ag-sol, Pt-sol etc.

Ostwald process is an industrial process for manufacturing HNO_3. Reactions are as follows :

(i) $4NH_3 + 5O_2 \xrightarrow[500\text{ K, 9 atm}]{\text{Pt gauge}} 3NO + 6H_2O$

(ii) $2NO + O_2 \longrightarrow 2NO_2$

(iii) $3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$

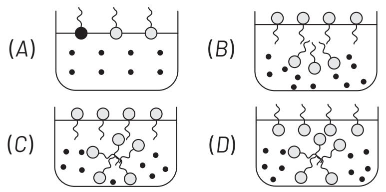
Mond process is associated with refining of nickel.

$$\underset{\text{Crude}}{Ni} + 4\,O \xrightarrow{80^\circ C} [Ni(CO)_4] \xrightarrow[-4\,CO]{200^\circ C} \underset{\text{Pure}}{Ni}$$

van Arkel method, ultra pure Zr, Hf, Ti metals get refined.

$$\underset{\text{Crude}}{Zr} + 4I_2 \xrightarrow{600\,^\circ C} ZrI_4(g) \xrightarrow[-2\,I_2]{1800^\circ C} \underset{\text{Pure}}{Zr}$$

46 Identify the correct molecular picture showing what happens at the critical micellar concentration (CMC) of an aqueous solution of a surfactant (● polar head; ∼ non-polar tail; • water). **[2020, 5 Sep Shift-I]**



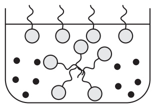
(a) (C) (b) (B)
(c) (D) (d) (A)

Ans. ***(d)***

CMC (critical micelle concentration) is the concentration of a surfactant in a bulk phase, above which aggregates of surfactant molecules, so called micelles, start to form.

A micelle is an aggregate of monomer surfactant molecules dispersed in a liquid colloid.

Hydrophilic 'Head' regions in contact with surrounding solvent, sequestering the hydrophobic 'Tail' regions in the micelle centre.



Hence, option (d) is correct.

47 Kraft temperature is the temperature **[2020, 6 Sep Shift-II]**

(a) below which the aqueous solution of detergents starts freezing
(b) below which the formation of micelles takes place
(c) above which the aqueous solution of detergents starts boiling
(d) above which the formation of micelles takes place

Ans. ***(d)***

Micelles formation take place only above a particular temperature called Kraft temperature (T_K).

Hence, the correct option is (d).

48 The flocculation value of HCl for arsenic sulphide sol. is 30 m mol L^{-1}. If H_2SO_4 is used for the flocculation of arsenic sulphide, the amount in grams of H_2SO_4 is 250 mL required for the above purpose is ...... (molecular mass of H_2SO_4 = 98 g / mol) **[2020, 7 Jan Shift-II]**

Ans. ***(0.37)***

(exact value : 0.3675 g)

Flocculation value = number of m mol of electrolyte needed per litre.

Since, As_2S_3 is negatively charged colloid, H^+ causes its flocculation.

Here, 30 m mol of HCl is needed per 1 L per 250 mL, HCl required would be

$$= \frac{30 \times 250}{1000} = 7.5 \text{ m mol}$$

$\therefore n_{H^+}$ required = 7.5 m mol

So, mol of H_2SO_4 required $= \frac{7.5 \text{ m mol}}{2}$

$= 3.75$ m mol

Mass of $H_2SO_4 = \frac{3.75 \times 98}{1000} = 0.3675$ g.

The value may range from 0.36 to 0.38.

49 As per Hardy-Schulze formulation, the flocculation values of the following for ferric hydroxide sol are in the order : **[2020, 8 Jan Shift-I]**

(a) $K_3[Fe(CN)_6] < K_2CrO_4 < AlCl_3 < KBr < KNO_3$

(b) $AlCl_3 > K_3[Fe(CN_6] > K_2CrO_4 > KBr = KNO_3$

(c) $K_3[Fe(CN)_6] < K_2CrO_4 < KBr = KNO_3 = AlCl_3$

(d) $K_3[Fe(CN)_6] > AlCl_3 > K_2CrO_4 > KBr > KNO_3$

Ans. ***(c)***

Ferric hydroxide sol (and other metal oxide and hydroxide sols) is generally positively charged. So, as per Hardy-Schulze rule, the flocculation power is greatest for electrolyte having most highly negatively charged anion.

$\therefore$ Flocculation power follow the order

$$\underset{\text{Anionic charge : }(-3)}{K_3[Fe(CN)_6]} > \underset{(-2)}{K_2CrO_4} > \underset{(-1)}{KBr} = KNO_3 = AlCl_3$$

As flocculation power increases, flocculation value decreases. Therefore, order of flocculation values is

$$K_3[Fe(CN)_6] < K_2CrO_4 < KBr = KNO_3 = AlCl_3$$

50 The aerosol is a kind of colloid in which **[2019, 9 April Shift-I]**

(a) gas is dispersed in liquid
(b) gas is dispersed in solid
(c) liquid is dispersed in water
(d) solid is dispersed in gas

Ans. ***(d)***

The aerosol is a kind of colloid in which solid is dispersed in gas. e.g. smoke, dust.

51 The correct option among the following is **[2019, 10 April Shift-II]**

(a) colloidal medicines are more effective, because they have small surface area.
(b) brownian motion in colloidal solution is faster if the viscosity of the solution is very high.
(c) addition of alum to water makes it unfit for drinking.
(d) colloidal particles in lyophobic sols can be precipitated by electrophoresis.

Ans. ***(d)***

The explanation of the given statements are as follows :

(a) Colloidal medicines are more effective because they (dispersed phase) have larger surface area.
Thus, option (a) is incorrect.

(b) Brownian motion of dispersed phase particles in colloidal solution is faster if the viscosity of the solution is very low. Thus, option (b) is incorrect.

(c) Addition of alum ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$), an electrolyte to water makes it fit for drinking purposes because alum coagulates mud particles from water.
Thus, option (c) is incorrect.

(d) Precipitation of lyophobic solution particles by electrophoresis is called cottrell precipitation.
Thus, option (d) is correct.

52 Peptisation is a **[2019, 12 April Shift-I]**

(a) process of bringing colloidal molecule into solution
(b) process of converting precipitate into colloidal solution
(c) process of converting a colloidal solution into precipitate
(d) process of converting soluble particles to form colloidal solution

Ans. ***(b)***

Peptisation is a process of converting precipitate into colloidal solution. This process involves the shaking of precipitate with the dispersion medium in the presence of small amount of electrolyte. The electrolyte added is called peptising agent.

During peptisation, the precipitate adsorbs one of the ions of the electrolyte on its surface. This causes the development of positive or negative charge on precipitates, which ultimately breakup into smaller particles of the size of a colloid.

53 Among the following, the incorrect statement about colloids is **[2019, 12 April Shift-II]**

(a) They can scatter light
(b) They are larger than small molecules and have high molar mass
(c) The osmotic pressure of a colloidal solution is of higher order than the true solution at the same concentration
(d) The range of diameters of colloidal particles is between 1 and 1000 nm

Ans. ***(c)***

Statement (c) is incorrect about colloids. Colligative properties such as relative lowering of vapour pressure, elevation in boiling point, depression in freezing point and osmotic pressure of a colloidal solution is of low order than the true solution at the same concentration.

54 Which of the salt-solution is most effective for coagulation of arsenious sulphide?

(a) $BaCl_2$ (b) $AlCl_3$ (c) Na_3PO_4 (d) NaCl **[2019, 9 Jan Shift-II]**

Ans. ***(b)***

Arsenious sulphide sol is a negative colloid, $As_2S_3.(S^{2-})$. So, it will be coagulated by the cation of an electrolyte.

According to the Hardy-Schulze rule, the higher the charge of the ion, the more effective it is in bringing about coagulation. Here, the cations available are Al^{3+} (from $AlCl_3$), Ba^{2+} (from $BaCl_2$) and Na^+ (from Na_3PO_4 and NaCl). So, their power to coagulate $As_2S_3.(S^{2-})$ will follow the order as

$$Al^{3+} > Ba^{2+} > Na^+$$

55 Haemoglobin and gold sol are examples of

(a) negatively and positively charged sols, respectively
(b) negatively charged sols
(c) positively charged sols
(d) positively and negatively charged sols, respectively

[2019, 10 Jan Shift-II]

Ans. ***(d)***

Haemoglobin and gold sol both are colloids and always carry an electric charge. Haemoglobin is a positively charged sol, because in haemoglobin, Fe^{2+} ion is the central metal ion of the octahedral complex.

All metal sols like, Au-sol, Ag-sol etc; are negatively charged sols.

56 An example of solid sol is

[2019, 11 Jan Shift-I]

(a) gem stones (b) hair cream
(c) butter (d) paint

Ans. ***(a)***

Solid sol consists of solid as both dispersed phase and dispersion medium. In gemstones, metal crystals (salt and oxides of metals) are dispersed in solid (stone) medium. Hair cream is an emulsion (liquid in liquid). Butter is a colloidal solution of liquid in solid. Paint is also sol (solid in liquid).

57 Among the colloids cheese (*C*), milk (*M*) and smoke (*S*), the correct combination of the dispersed phase and dispersion medium, respectively is **[2019, 11 Jan Shift-II]**

(a) *C* : liquid in solid; *M* : liquid in liquid; *S* : solid in gas
(b) *C* : solid in liquid; *M* : liquid in liquid; *S* : gas in solid
(c) *C* : liquid in solid; *M* : liquid in solid; *S* : solid in gas
(d) *C* : solid in liquid; *M* : solid in liquid; *S* : solid in gas

Ans. ***(a)***

Dispersed phase	Dispersion medium	Type of colloid	Examples
Liquid	Solid	Gel	Cheese (C), butter, jellies
Liquid	Liquid	Emulsion	Milk (M), hair cream
Solid	Gas	Aerosol	Smoke (S), dust

Thus, *C* : liquid in solid, *M* : liquid in liquid and *S* : solid in gas.

58 Among the following, the false statement is

(a) Tyndall effect can be used to distinguish between a colloidal solution and a true solution
(b) It is possible to cause artificial rain by throwing electrified sand carrying charge opposite to the one on clouds from an aeroplane
(c) Lyophilic sol can be coagulated by adding an electrolyte
(d) Latex is a colloidal solution of rubber particles which are positively charged

[2019, 12 Jan Shift-II]

Ans. ***(d)***

Statement given as statement (d) is incorrect. Latex is a stable dispersion, i.e. emulsion of polymer microparticles in an aqueous medium.

These microparticles belong to rubber and are negatively charged in nature. Natural latex contains some amount of sugar, resin, protein and ash as well.

The closest synthetic latex that can be associated with the properties of natural latex is SBR, i.e. Styro Butane Rubber.

Rest of all the statements are correct.

59 The Tyndall effect is observed only when following conditions are satisfied **[JEE Main 2017]**

I. The diameter of the dispersed particles is much smaller than the wavelength of the light used.
II. The diameter of the dispersed particle is not much smaller than the wavelength of the light used.
III. The refractive indices of the dispersed phase and dispersion medium are almost similar in magnitude.
IV. The refractive indices of the dispersed phase and dispersion medium differ greatly in magnitude.

(a) I and IV (b) II and IV
(c) I and III (d) II and III

Ans. ***(b)***

Colloidal solutions show Tyndall effect due to scattering of light by colloidal particles in all directions in space. It is observed only under the following conditions.

(i) The diameter of the colloids should not be much smaller than the wavelength of light used.
(ii) The refractive indices of the dispersed phase and dispersion medium should differ greatly in magnitude.

60 The coagulating power of electrolytes having ions Na^+, Al^{3+} and Ba^{2+} for arsenic sulphide sol increases in the order

[JEE Main 2013]

(a) $Al^{3+} < Ba^{2+} < Na^+$
(b) $Na^+ < Ba^{2+} < Al^{3+}$
(c) $Ba^{2+} < Na^{2+} < Al^{3+}$
(d) $Al^{3+} < Na^+ < Ba^{2+}$

Ans. ***(b)***

According to Hardy Schulze rule, greater the charge on oppositely charged ion, greater is its coagulating power. Since arsenic sulphide is a negatively charged sol, thus, the order of coagulating power is $Na^+ < Ba^{2+} < Al^{3+}$.

61 Gold numbers of protective colloids *A*, *B*, *C* and *D* are 0.50, 0.01, 0.10 and 0.005, respectively. The correct order of their protective powers is **[AIEEE 2008]**

(a) $D < A < C < B$
(b) $C < B < D < A$
(c) $A < C < B < D$
(d) $B < D < A < C$

Ans. ***(c)***

Higher the gold number, lesser will be the protective power of colloid.

62 The disperse phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged, respectively. Which of the following statement is not correct?

(a) Coagulation in both sols can be brought about by electrophoresis
(b) Mixing the sols has no effect
(c) Sodium sulphate solution causes coagulation in both sols
(d) Magnesium chloride solution coagulates the gold sol more readily than the iron (III) hydroxide sol **[AIEEE 2005]**

Ans. ***(b)***

Mixing the sols together can cause coagulation, since the charges are neutralised.