JEE ADVANCED DRILL

A collection of 30 innovative problems on JEE Advanced pattern from complete syllabus

Single Answer Correct Type

1. Select the incorrect statement among the following.

(a) The first ionisation potential of Al is less than the first ionisation potential of Mg

(b) The second ionisation potential of Mg is greater than the second ionisation potential of Na

(c) The first ionisation potential of Na is less than the first ionisation potential of Mg

(d) The third ionisation potential of Mg is greater than third ionisation potential of Na

2. For the elementary reaction, $M \longrightarrow N$, the rate of disappearance of M increases by a factor of 8 upon doubling the concentration of M. The order of the reaction with respect to M is [JEE Advanced 2014]

(a) 4 *(b)* 3

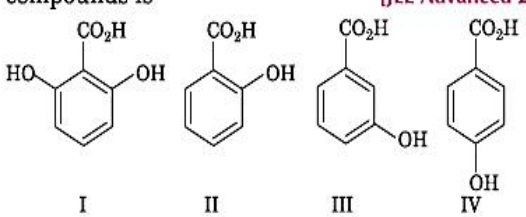
(c) 2 *(d)* 1

3. One mole of an ideal gas expands against a constant external pressure of 1 atm from a volume of 10 dm^3 to a volume of 30 dm^3. What would be the work done by the gas in joules?

(a) – 2026 J *(b)* – 2.026 J

(c) – 1947 J *(d)* 1648 J

4. The correct order of acidity for the following compounds is [JEE Advanced 2016]



I II III IV

(a) I > II > III > IV *(b)* III > I > II > IV

(c) III > IV > II > I *(d)* I > III > IV > II

5. Among the following, the surfactant that will form micelles in aqueous solution at the lowest molar concentration and ambient conditions, is

(a) $CH_3(CH_2)_{15}\overset{+}{N}(CH_3)_3Br^-$ *(b)* $CH_3(CH_2)_{11}OSO_3^-Na^+$

(c) $CH_3(CH_2)_{11}\overset{+}{N}(CH_3)_3Br^-$ *(d)* $CH_3(CH_2)_6COO^-Na^+$

One or More than One Answer Correct Type

6. The correct statement(s) about Cr^{2+} and Mn^{3+} is/are [Atomic number of Cr = 24 and Mn = 25]. [JEE Advanced 2015]

(a) Cr^{2+} is a reducing agent

(b) Mn^{3+} is an oxidising agent

(c) Both Cr^{2+} and Mn^{3+} exhibit d^4 electronic configuration

(d) When Cr^{2+} is used as a reducing agent, the chromium ion attains d^5 electronic configuration

7. The nuclear reaction accompanied with emission of neutron(s) are

(a) $^{27}_{13}Al + {}^{4}_{2}He \longrightarrow {}^{30}_{15}P$

(b) $^{12}_{6}C + {}^{1}_{1}H \longrightarrow {}^{13}_{7}N$

(c) $^{30}_{15}P \longrightarrow {}^{30}_{14}Si + {}^{0}_{1}e$

(d) $^{241}_{96}Cm + {}^{4}_{2}He \longrightarrow {}^{244}_{97}Bk + {}^{0}_{1}e$

8. Which of the following inorganic compound(s) exhibit octahedral geometry?

(a) IF_7 *(b)* SeF_6

(c) BrF_5 *(d)* SF_4

9. Addition of high proportions of manganese makes steel useful in making rails because it

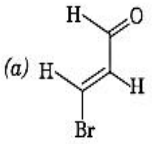
(a) gives hardness to steel

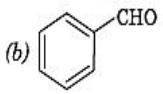
(b) helps the formation of oxides of iron

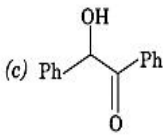
(c) can remove oxygen and sulphur

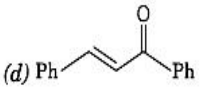
(d) can show highest oxidation state of + 7

10. Positive Tollen's test is observed for [JEE Advanced 2016]

(a) 

(b) 

(c) 

(d) 

11. In the brown ring test for NO_3^- ion, complex $[Fe(H_2O)_5NO]^{2+}$ is formed. In this complex

(a) NO transfers its electron to Fe^{2+} such that iron is Fe^+ and NO is NO^+

(b) Three unpaired electrons are present so that its magnetic moment is 3.87 BM

(c) The colour is due to charge transfer

(d) Two unpaired electrons are present so that its magnetic moment is 1.414

12. Which of the following statements are correct?

(a) The pH of 1×10^{-8} M solution of HCl is 8

(b) The conjugate base of $H_2PO_4^-$ is HPO_4^{2-}

(c) Autoprotolysis constant of water increases with temperature

(d) When a solution of a weak monoprotic acid is titrated against a strong base, at half-neutralisation point, $pH = \left(\frac{1}{2}\right) pK_a$

13. Choose the correct reasons for the stability of the lyophobic colloidal particles.

(a) Preferential adsorption of ions on their surface from the solution

(b) Preferential adsorption of solvent on their surface from the solution

(c) Attraction between different particles having opposite charges on their surface

(d) Potential difference between the fixed layer and the diffused layer of opposite charges around the colloidal particles

Single Integer Type

14. Phosphorus has eight electrons in the penultimate shell. It exists in X form. When this X combines with oxygen, it readily forms Y which is a waxy solid having white colour. The number of P—O—P bonds in the Y is/are

15. The maximum number of electrons in principal quantum number, $n = 3$ and spin quantum number, $m_s = -\frac{1}{2}$ is/are

16. If the freezing point of a 0.01 molal aqueous solution of a cobalt (III) chloride-ammonia complex (which behaves as a strong electrolyte) is $-0.0558°C$, the number of chloride(s) in the coordination sphere of the complex is (K_f of water = 1.86 K kg mol^{-1}) [JEE Advanced 2015]

17. Consider the following reactions,

I. $2S(l) + Cl_2(g) \longrightarrow P(l)$

II. $SO_2 + PCl_5 \longrightarrow P + Q$

III. $Fe(OH)_3 + 3SOCl_2 \longrightarrow P + Q + R$

IV. $CH_3COOH + SOCl_2 \longrightarrow P + Q + R$

How many of these reactions produce SO_2 as by-product?

18. The total number of alkenes formed by dehydrobromination of 3-bromo-3-cyclopentylhexane using alcoholic KOH is

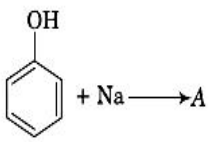
19. The following reaction is non-spontaneous at 25°C,

$$Cu_2O(s) \rightleftharpoons 2Cu(s) + \frac{1}{2}O_2(g); \Delta_r G° = 141 \text{ kJ}$$

If $\Delta_r S° = 75.18$ JK^{-1} and temperature above $(2170 + x)$, the reaction becomes spontaneous. Calculate the value of x.

20. A sample of AgCl was treated with 5 mL of 1.5 M Na_2CO_3 solution to give Ag_2CO_3. The remaining solution contained 0.0026 g of Cl^- ions per litre. The solubility product of AgCl is $x \times 10^{-8}$ ($K_{sp}(Ag_2CO_3) = 8.2 \times 10^{-12}$]. Calculate the value of x.

21. The number of resonance structure(s) for A is



Comprehension I

Tollen's reagent is used for the detection of aldehydes. When a solution of $AgNO_3$ is added to glucose with NH_4OH, then gluconic acid is formed

$$Ag^+ + e^- \longrightarrow Ag; E°_{red} = 0.80 \text{ V}$$

$$C_6H_{12}O_6 + H_2O \longrightarrow \underset{\text{Gluconic acid}}{C_6H_{12}O_7} + 2H^+ + 2e^-; \quad E°_{oxi} = -0.05 \text{ V}$$

$$[Ag(NH_3)_2]^+ + e^- \longrightarrow Ag(s) + 2NH_3; E°_{red} = 0.337 \text{ V}$$

$$\left(\text{Use } 2.303 \times \frac{RT}{F} = 0.0592 \text{ and } \frac{F}{RT} = 38.92 \text{ at } 298 \text{ K}\right)$$

22. $2Ag^+ + C_6H_{12}O_6 + H_2O \longrightarrow 2Ag(s) + C_6H_{12}O_7 + 2H^+$

Find $\ln K$ of this reaction.

(a) 66.13 (b) 58.38

(c) 28.30 (d) 46.29

23. When ammonia is added to the solution, pH is raised to 11. Which half- cell reaction is affected by pH and by how much?

(a) E_{oxi} will increase by a factor of 0.65 from $E°_{oxi}$

(b) E_{oxi} will decrease by a factor of 0.65 from $E°_{oxi}$

(c) E_{red} will increase by a factor of 0.65 from $E°_{red}$

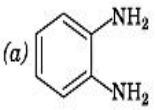
(d) E_{red} will decrease by a factor of 0.65 from $E°_{red}$

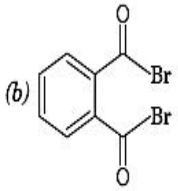
Comprehension II

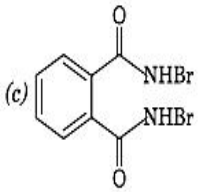
Treatment of compound O with $KMnO_4/H^+$ gave P, which on heating with ammonia gave Q. The compound Q on treatment with $Br_2/NaOH$ produced R. On strong heating, Q gave S, which on further treatment with ethyl 2-bromopropanoate in the presence of KOH followed by the acidification, gave a compound T.


(O)

24. The compound R is [JEE Advanced 2016]

(a) 

(b) 

(c) 

(d) 

25. The compound T is

(a) glycine (b) alanine (c) valine (d) serine

Comprehension III

Boron forms many compounds like boric acid, borax and inorganic graphite etc. Orthoboric acid contains triangular BO_3^{3-} units. In the solid, the $B(OH)_3$ units are bonded through hydrogen bonding into 2D sheets with almost hexagonal symmetry. Borax is used in borax bead test.

26. The number of the H-atoms replaced from boric acid, when it is dissolved in water is

(a) two (b) one (c) three (d) zero

27. Boric acid can behave as a strong acid in the presence of

(a) anhyd. H_2SO_4 (b) glycerol

(c) mannitol (d) All of these

Matrix Match Type

28. Match the anionic species given in Column I that are present in the ore(s) given in Column II. [JEE Advanced 2015]

Column I	Column II
A. Carbonate	p. Siderite
B. Sulphide	q. Malachite
C. Hydroxide	r. Bauxite
D. Oxide	s. Calamine
	t. Argenite

Codes

	A	B	C	D
(a)	q,s	s,t	r	p
(b)	p,q,s	t	q,r	r
(c)	q,r	p,s	t	r
(d)	p,s	q,t	s	t

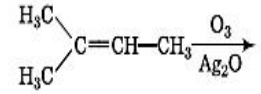
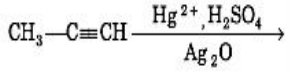
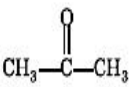
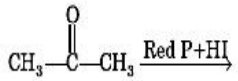
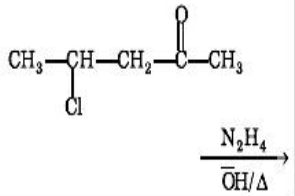
29. Match the crystal system/unit cells mentioned in Column I with their characteristics features mentioned in Column II.

Column I	Column II
A. Simple cubic and face-centred cubic	p. Have these cell parameters $a = b = c$ and $\alpha = \beta = \gamma = 90°$
B. Cubic and rhombohedral	q. Are two crystal systems
C. Cubic and tetragonal	r. Have only two crystallographic angles of 90°
D. Hexagonal and monoclinic	s. Belong to same crystal system

Codes

	A	B	C	D
(a)	p	q,s	r	s
(b)	p,s	q	q	q,r
(c)	q,s	r	p	q
(d)	q	p,s	q,r	q

30. Match the Column I with Column II.

Column I	Column II
A. 	p. Reduction
B. 	q. 
C. 	r. Oxidation reaction
D. 	s. 

Codes

	A	B	C	D
(a)	q,r	q,r	p	p,s
(b)	p	q	r	s
(c)	p,q	q,s	p,r	p,s
(d)	s	r	p,s	q

Answers with Explanation

1. ***(b)*** (a) In a period, element of 2nd group has higher first ionisation potential than element of group 13.

(b) Mg^+ require less energy for further ionisation than Na^+ because of noble gas configuration of Na^+.

(c) Ionisation energy increases from left to right in a period.

(d) Mg^{2+} has noble gas configuration, require greater energy for further ionisation than Na^{2+}.

2. ***(b)*** For the elementary reaction,

$$M \longrightarrow N$$

Rate law can be written as $\text{Rate} \propto [M]^n$

$$\text{Rate} = k[M]^n \quad \ldots(i)$$

when we double the concentration of M, rate becomes 8 times, hence new rate law can be written as

$$8 \times \text{rate} = k[2M]^n \quad \ldots(ii)$$

Divide Eq. (i) by Eq. (ii)

$$\frac{\text{Rate}}{8 \times \text{Rate}} = \frac{k[M]^n}{k[2M]^n}$$

$$\frac{1}{8} = \frac{1}{[2]^n}$$

$$[2]^n = 8 = [2]^3 \Rightarrow n = 3$$

3. ***(a)*** We know that, $w = -\int_{V_1}^{V_2} pdV = -p(V_2 - V_1)$

$$= -(1 \text{ atm})(30 \text{ dm}^3 - 10 \text{ dm}^3) = -20 \text{ dm}^3 \text{ atm}$$

But we have to find the result in joules,

As, $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1} = 0.08206 \text{ dm}^3 \text{ atm K}^{-1}\text{mol}^{-1}$

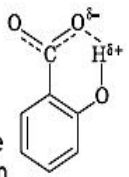
$$1 \text{ atm} = \frac{8.314 \text{ JK}^{-1}\text{mol}^{-1}}{0.08206 \text{ dm}^3\text{K}^{-1}\text{mol}^{-1}}$$

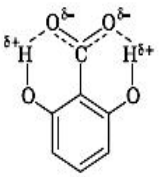
$\because$ $w = -20 \text{ dm}^3 \text{ atm}$

$\therefore$ $$w = -20 \text{ dm}^3 \times \frac{8.314 \text{ JK}^{-1}\text{mol}^{-1}}{0.08206 \text{ dm}^3\text{K}^{-1}\text{mol}^{-1}}$$

$$= -2026.32 \text{ J}$$

4. ***(a)*** Thinking process $\bar{O}H$ group displays both kinds of effect, an electron withdrawing acid-strengthening inductive effect from the *meta*-position and an electron-releasing acid weakening resonance effect from the *para*-position (at this position, resonance effect overweighs the inductive effect).


(II)


(I)
Most stable

Thus, III > IV, *o*-hydroxybenzoic acid (II) is far stronger than the corresponding *meta* and *para*-isomers as the carboxylate ion is stabilised by intramolecular H-bonding.

2,6-dihydroxybenzoic acid(I) forms carboxylate ion which is further stabilised by intramolecular H-bonding. Thus, correct order is I > II > III > IV.

5. ***(a)*** Larger the hydrophobic fragment of surfactant, easier will be the micellisation, smaller the critical micelle concentration. Therefore, $CH_3(CH_2)_{15}\overset{+}{N}(CH_3)_3Br^-$ will have the lowest critical micelle concentration.

6. ***(a, b, c)*** Key concept In a redox reaction, the atom/ion which get oxidised behaves as a reducing agent and which is reduced behaves as an oxidising agent.

$$Cr^{2+} + Mn^{3+} \rightleftharpoons Cr^{3+} + Mn^{2+}$$

Since, Cr^{2+} loses an electron to convert into Cr^{3+}, (a more stable state of Cr), so it is a reducing agent whereas, Mn^{3+} gains an electron from Cr^{2+} to get its stable state Mn^{2+}. Hence, it is an oxidising agent.

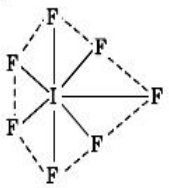
Electronic configuration of $Cr^{2+} = [Ar]_{18}3d^4 4s^0$

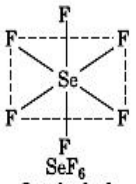
Electronic configuration of $Mn^{3+} = [Ar]_{18}\ 3d^4 4s^0$

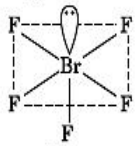
Therefore, both Cr^{2+} and Mn^{3+} have d^4 outermost electronic configuration.

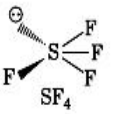
7. ***(a, d)*** If sum of mass number of product nuclides is less than the sum of parent nuclides, then neutron emission will occur. In both (a) and (d), sum of mass number of product nuclides is one unit less than the sum of parent nuclides, neutron emission will balance the mass number.

8. ***(b, c)***

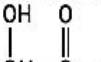

IF_7
Pentagonal bipyramidal


SeF_6
Octahedral


BF_5
Octahedral

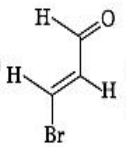

SF_4
Trigonal planar

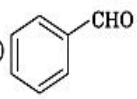
9. ***(a, c)*** Addition of manganese to iron improves hardness of steel as well as remove oxygen and sulphur.

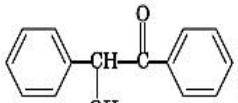
10. ***(a, b, c)*** Key concept Tollen's test is given by all aldehydes and all reducing sugars such as glucose, fructose and α-hydroxy ketones. 

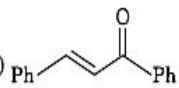
$$RCHO + Ag_2O \xrightarrow{^-OH} RCOOH + 2Ag\downarrow$$

(Tollen's reagent) (Silver mirror)

(a)  having an aldehyde group gives Tollen's test.

(b)  is an aldehyde that gives positive Tollen's test.

(c)  gives positive Tollen's test (α-hydroxy ketone).

(d)  is a ketone, hence does not give Tollen's test.

11. *(a, b, c)*

$$NO \longrightarrow NO^+ + e^-$$

$$Fe^{2+} + e^- \longrightarrow Fe^+$$

$3d^6$ (4 unpaired electrons) $\longrightarrow$ $3d^7$ (3 unpaired electrons)

Magnetic moment, μ for $Fe^+ = \sqrt{n(n+2)}\ BM = \sqrt{3 \times 5}\ BM$

$= 3.87\ BM$

12. *(b, c)* pH of 10^{-8} M solution will be between 6 and 7 but never 8. The conjugate base of an acid is formed by removing a proton (H^+) from acid. Therefore, HPO_4^{2-} is a conjugate base of $H_2PO_4^-$

$$H_2O \rightleftharpoons H^+ + \bar{O}H,\ \Delta H > 0$$

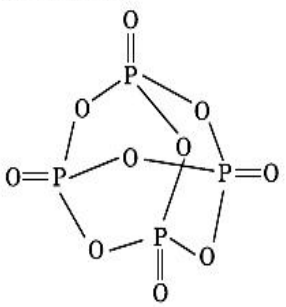
Increasing temperature will increase equilibrium constant of the above endothermic reaction.

13. *(a, d)* Lyophobic sol, which is otherwise unstable, gets stabilised by preferential adsorption of ions on their surface, thus developing a potential difference between the fixed layer and the diffused layer.

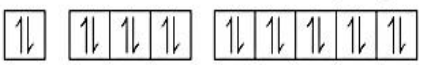
14. *(6)* There are six P—O—P bonds in the *Y* molecules.

$$P_4 + 5O_2 \xrightarrow{\Delta} P_4O_{10}$$

The structure of P_4O_{10} is



15. *(9)* When $n = 3, l = 0, 1, 2$, i.e. there are 3*s*, 3*p* and 3*d*-orbitals. If all these orbitals are completely occupied as



Total 18 electrons, 9 electrons with

$$m_s = +\frac{1}{2} \text{ and 9 with } m_s = -\frac{1}{2}$$

Short tricks In any *n*th orbit, there can be a maximum of $2n^2$ electrons. Hence, when $n = 3$, number of maximum electrons = 18. Out of these 18 electrons, 9 can have spin $-\frac{1}{2}$ and remaining nine with spin $+\frac{1}{2}$.

16. *(1)* Given, ΔT_f = depression in freezing point = – 0.0558°C

m = molality = 0.01

According to the formula,

$$\Delta T_f = K_f \times i \times m \quad [\text{where, } i = \text{van't Hoff factor}]$$

$$\Rightarrow \quad i = \frac{\Delta T_f}{K_f \times m} = \frac{0.0558}{1.86 \times 0.01} = 3$$

$i = 3$, indicates that there are three ions in the given complex. Also, given complex behaves as a strong electrolyte, hence $\alpha = 100\%$.

Finally, complex becomes

$$\underset{\text{Coordination sphere}}{[Co(NH_3)_5Cl]} \qquad \underset{\text{Ionisation sphere}}{Cl_2}$$

Therefore, number of Cl^- ions in the coordination sphere of the complex = 1.

17. *(2)*

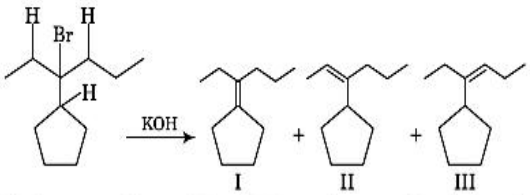
I. $2S(l) + Cl_2(g) \longrightarrow \underset{P}{S_2Cl_2(l)}$

II. $SO_2 + PCl_5 \longrightarrow \underset{P}{SOCl_2} + \underset{Q}{POCl_3}$

III. $Fe(OH)_3 + 3SOCl_2 \longrightarrow \underset{P}{3SO_2} + \underset{Q}{3HCl} + \underset{R}{FeCl_3}$

IV. $CH_3COOH + SOCl_2 \longrightarrow \underset{P}{CH_3COCl} + \underset{Q}{SO_2} + \underset{R}{HCl}$

18. *(5)* The substrate has three different types of B—H, therefore, three structural isomers of alkenes are expected.



The last two alkenes II and III are also capable of showing geometrical isomerism, hence, two geometrical isomers for each of them will be counted giving a total of five isomers.

19. *(6)* At $T = 25°C = 298$ K, we have

$$\Delta G = \Delta H - T\Delta S$$

$$141 = \Delta H - 298 \times 0.0758$$

$$\Delta H = 141 + 298 \times 0.0758 = 163.6\ kJ$$

The temperature above which the reaction becomes spontaneous under standard conditions corresponds to $\Delta G = 0$ and is given by

$$T = \frac{\Delta H}{\Delta S}$$

Substituting the values of ΔH and ΔS, it gives

$$T = \frac{163.6 \times 10^3 J}{75.18\ JK^{-1}} = 2176\ K$$

Above 2176 K, the reaction will become spontaneous.

As $T = 2176$ K

So, $T = (2170 + 6)$ K

Hence, $x = 6$

20. *(2)* $2AgCl(s) + CO_3^{2-} \rightleftharpoons Ag_2CO_3(s) + 2Cl^-$

$$K = \frac{[Cl^-]^2}{[CO_3^{2-}]} = \frac{[Cl^-]^2}{[CO_3^{2-}]} \times \frac{[Ag^+]^2}{[Ag^+]^2} = \frac{[K_{sp}(AgCl)]^2}{K_{sp}(Ag_2CO_3)}$$

$$[Cl^-] = \frac{0.0026}{35.5}\ M = 7.3 \times 10^{-5}\ M$$

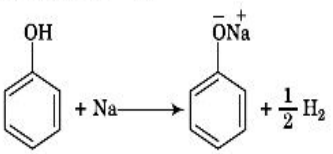
The above concentration of Cl^- indicates that $[CO_3^{2-}]$ remains almost unchanged.

$$\frac{7.3 \times 10^{-5}}{1.5} = \frac{[K_{sp}(AgCl)]^2}{8.2 \times 10^{-12}}$$

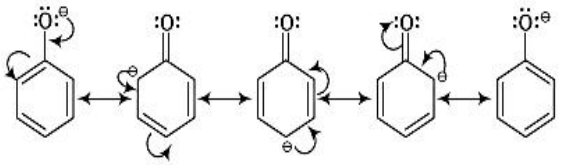
$$K_{sp}(AgCl) = 2 \times 10^{-8}$$

$\therefore$ The value of $x = 2$

21. *(5)*



Phenoxide ion undergoes resonance and get stabilised.



22. *(b)* For $2Ag^+ + C_6H_{12}O_6 + H_2O \rightleftharpoons 2Ag(s) + C_6H_{12}O_7 + 2H^+;\ E^\circ = 0.75\ V$

$$\text{Also, } E^\circ = \frac{0.0592}{2}\log K \Rightarrow \log K = \frac{2E^\circ}{0.0592} = 25.33$$

$$\ln K = 2.303 \log K = 58.33$$

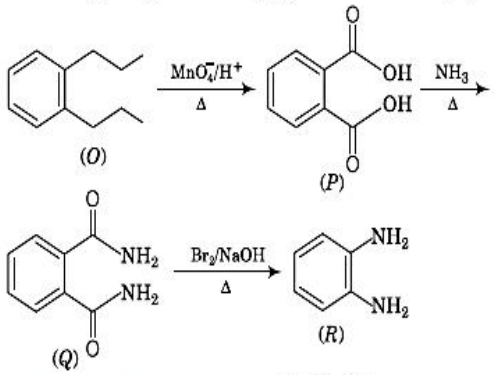
23. *(c)* On increasing concentration of NH_3, the concentration of H^+ ion decreases

$$\therefore \quad E_{red} = E^\circ_{red} - \frac{0.0592}{2}\log [H^+]^2$$

$$= 0 - \frac{0.0592}{2} \times 2\log 10^{-11} = 0.65\ V$$

Hence, E_{red} increases by 0.65 V

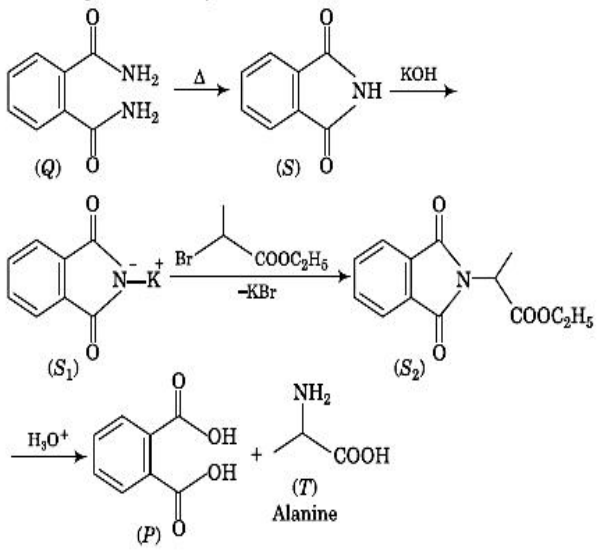
24. *(a)* **Key concept** Any alkyl group with atleast one H at α-carbon, e.g. $-CH_2OH$, $-CH_2NH_2$, $-CH_2Cl$ is oxidised to $-COOH$ by MnO_4^-/H^+. Thus, *(O)* is converted to *(P)*.



25. *(b)* **Key concept** (i) $RCONH_2 \xrightarrow{Br_2/NaOH} RNH_2$

It is called Hofmann bromamide degradation reaction. Thus, *(Q)* changes to *(R)*.

(ii) Conversion of *(S)* into *(T)* through S_1, S_2 is called Gabriel phthalimide reaction. *P* is formed by cleavage of amide linkage in Gabriel phthalimide reaction.

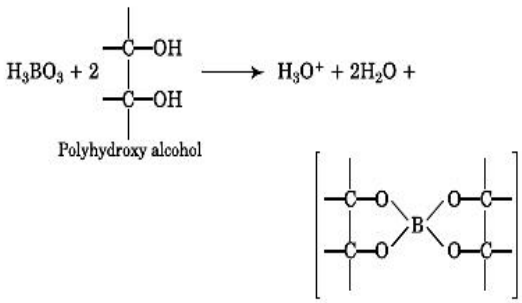


26. *(d)* Boric acid when dissolved in water only one H^+ ion is removed to form $[B(OH)_4]^-$

$$H_3BO_3 + H_2O \rightleftharpoons [B(OH)_4]^- + H^+$$

There is no replacement of H-atom, from H_3BO_3 occurs in the above reaction.

27. *(d)* In the presence of anhyd. H_2SO_4, glycerol or mannitol, boric acid furnishes H^+ ions, so it act as a strong acid.



28. *(b)*

	Ore	Formula
p.	Siderite	$FeCO_3$
q.	Malachite	$CuCO_3 \cdot Cu(OH)_2$
r.	Bauxite	$AlO_x(OH)_{3-2x}$
s.	Calamine	$ZnCO_3$
t.	Argentite	Ag_2S

Hence, the correct match is A → p,q,s; B → t; C → q,r; D → r

29. *(b)*

A. Simple cubic and face-centred cubic both have cell parameters $a = b = c$ and $\alpha = \beta = \gamma = 90°$ Also, both of them belongs to same cubic crystal system.

B. The cubic and rhombohedral crystal system belongs to different crystal system.

C. Cubic and tetragonal are two different types of crystal system having different cell parameters.

D. Hexagonal and monoclinic are two different crystal system and both have two of their crystallographic angles of 90°.

30. *(a)* A → q,r; B → q,r; C → p; D → p, s