JEE (ADVANCED) 2025 PAPER-1

[PAPER, ANSWER KEY WITH SOLUTION]

HELD ON SUNDAY 18 TH MAY 2024

CHEMISTRY

SECTION 1 (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

  Full Marks : +3 If **ONLY** the correct option is chosen;

  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks : −1 In all other cases.

[Q.1] The heating of NH_4NO_2 at 60-70°C and NH_4NO_3 at 200-250°C is associated with the formation of nitrogen containing compound X and Y, respectively, X and Y, respectively, are

[A] N_2 and N_2O [B] NH_3 and NO_2 [C] NO and N_2O [D] N_2 and NH_3

[ANS] **A**

[SOLN] $NH_4NO_2 \xrightarrow{60-70^\circ C} \underset{(X)}{N_2(g)} + H_2O$

$NH_4NO_3 \xrightarrow{200-250^\circ C} \underset{(Y)}{N_2O(g)} + 2H_2O$

[Q.2] The correct order of the wavelength maxima of the absorption band in the ultraviolet-visible region for the given complexes is

[A] $\left[Co(CN)_6\right]^{3-} < \left[Co(NH_3)_6\right]^{3+} < \left[Co(NH_3)_5(H_2O)\right]^{3+} < \left[Co(NH_3)_5(Cl)\right]^{2+}$

[B] $\left[Co(NH_3)_5(Cl)\right]^{2+} < \left[Co(NH_3)_5(H_2O)\right]^{3+} < \left[Co(NH_3)_6\right]^{3+} < \left[Co(CN)_6\right]^{3-}$

[C] $\left[Co(CN)_6\right]^{3-} < \left[Co(NH_3)_5(Cl)\right]^{2+} < \left[Co(NH_3)_5(H_2O)\right]^{3+} < \left[Co(NH_3)_6\right]^{3+}$

[D] $\left[Co(NH_3)_6\right]^{3+} < \left[Co(CN)_6\right]^{3-} < \left[Co(NH_3)_5(Cl)\right]^{2+} < \left[Co(NH_3)_5(H_2O)\right]^{3+}$

[ANS] **A**

[SOLN] Octahedral Complex $\boxed{(\lambda_{ab}\ max) \propto \frac{1}{\Delta_0}}$

$$\Delta_O :- \left[Co(CN)_6\right]^{3-} > \left[Co(NH_3)_6\right]^{3+} > \left[Co(NH_3)_5(H_2O)\right]^{3+} > \left[Co(NH_3)_5Cl\right]^{2+}$$

$$(\lambda_{abs})_{maxn} \underset{\downarrow 535\ nm}{\left[Co(NH_3)_5Cl\right]^{2+}} > \underset{\downarrow 500\ nm}{\left[Co(NH_3)_5(H_2O)\right]^{3+}} \underset{\downarrow 475\ nm}{\left[Co(NH_3)_6\right]^{3+}} < \underset{\downarrow 310\ nm}{\left[Co(CN)_6\right]^{-3}}$$

[Q.3] One of the products formed from the reaction of permanganate ion with iodide ion in neutral aqueous medium is

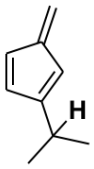
[A] I_2 [B] IO_3^- [C] IO_4^- [D] IO_2^-

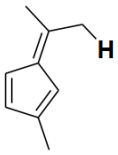
[ANS] **B**

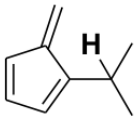
[SOLN] In neutral aqueous or faintly alkaline medium permanganate ion oxidized Iodide ion to Iodate ion

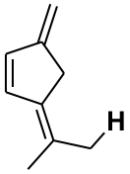
$$2Mno_4^{\ominus} + H_2O + I^{\ominus} \longrightarrow 2MnO_2 + 2OH^{\ominus} + IO_3^{\ominus}$$

[Q.4] Consider the depicted hydrogen (H) in the hydrocarbons given below. The most acidic hydrogen (H) is

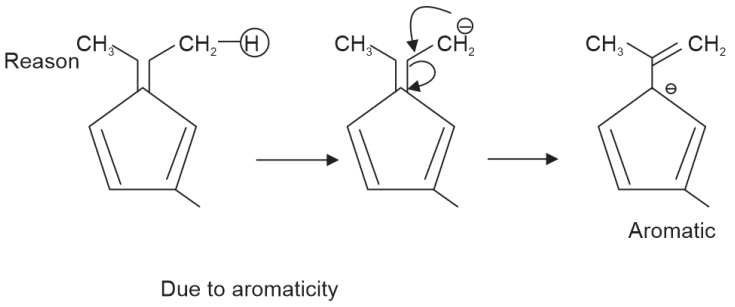
[A] 

[B] 

[C] 

[D] 

[ANS] **B**

[SOLN] 

Due to aromaticity

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**
  Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;
  Partial Marks : +3 If all the four options are correct but **ONLY** three options are chosen;
  Partial Marks : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

Partial Marks : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : −2 In all other cases.

- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
choosing ONLY (A), (B) and (D) will get +4 marks;
choosing ONLY (A) and (B) will get +2 marks;
choosing ONLY (A) and (D) will get +2 marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 mark;
choosing ONLY (B) will get +1 mark;
choosing ONLY (D) will get +1 mark;
choosing no option (i.e. the question is unanswered) will get 0 marks; and
choosing any other combination of options will get −2 marks.

[Q.5] Regarding the molecular orbital (MO) energy levels for homonuclear diatomic molecules, the INCORRECT statement(s) is(are)

[A] Bond order of Ne_2 is zero.

[B] The highest occupied molecular orbital (HOMO) of F_2 is σ-type.

[C] Bond energy of O_2^+ is smaller than the bond energy of O_2.

[D] Bond length of Li_2 is larger than the bond length of B_2.

[ANS] **BC**

[SOLN] (A) $Ne_2\,(e=20)\sigma 1s^2\sigma^*1s^2\sigma 2s^2\sigma^* 2s^2\sigma 2p_z^2 \quad \pi 2p_x{}^2=\pi^2 2p_y \;\pi^* 2px^2=\pi^* 2py^2 \quad \sigma^* 2pz^2$

$$B.O=\frac{10-10}{2}=0$$

(B) $F_2\,(e=18)$

$$\sigma(1s)^2\;\sigma^*(1s)^2\;\sigma 2s^2\sigma^* 2s^2\sigma 2pz^2\;\pi 2p_x{}^2=\pi^2 2p_{y_{(HOMO)}}{}^{\pi^{*2}_{2px}=\pi^{*2}_{2py}}\;\sigma^* 2py$$

(C) $\dfrac{O_2^+}{B.O=2.5} > \dfrac{O_2}{B.O=2.0}$ – Bond energy

$\boxed{B.O \propto B.E}$

(D) $Li_2\,(e=6)\sigma 1s^2\sigma^* 1s^2\sigma 2s^2 = KK^*\sigma 2s^2$

$B.O=1.0$ (bond is σ bond)

B.L= 266 pm

$B_2\,(e=10)\sigma(1s^2)\sigma^*(1s^2)\sigma 2s^2\sigma^* 2s^2 \quad \pi 2p_x^1=\pi^1 2p_y$

$=KK^*LL^*\pi^2 p_x^1=\pi 2p_y^1$

B. O = 1.0 (Bond is π bond & if bond is σ then B. L = 160 pm)

[Q.6] The pair(s) of diamagnetic ions is(are)

[A] La^{3+}, Ce^{4+} [B] Yb^{2+}, Lu^{3+} [C] La^{2+}, Ce^{3+} [D] Yb^{3+}, Lu^{2+}

[ANS] **AB**

[SOLN] Pair of diamagnetic ions:-

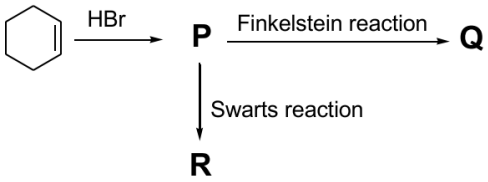
(A) $La^{3+}, Ce^{4+}, -4f^0$ with diamagnetic

(B) $La^{3+}, Ce^{4+}, -4f^{14}$ both diamagnetic

(C) $\underset{(5d^1)}{La^{2+}}, Ce^{3+} \rightarrow 4f^1$ – Both paramagnetic

(D) $\underset{(4f^{13})}{Yb^{3+}}, Lu^{2+} \rightarrow 4f^{14}\ 5d^1$ – Both Paramagnetic

[Q.7] For the reaction sequence given below, the correct statement(s) is(are)



(In the options, X is any atom other than carbon and hydrogen, and it is different in P, Q and R)

[A] C−X bond length in P, Q and R follows the order Q > R > P.

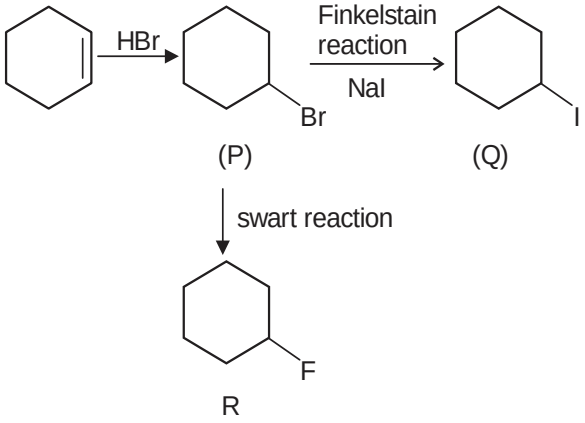
[B] C−X bond enthalpy in P, Q and R follows the order R > P > Q.

[C] Relative reactivity toward SN_2 reaction in P, Q and R follows the order P > R > Q.

[D] pK_a value of the conjugate acids of the leaving groups in P, Q and R follows the order R > Q > P.

[ANS] **B**

[SOLN]



Bond enthalpy depends on bond dissociation energy

So B.D.E order is R > P > Q

so bond enthalpy is R > P > Q

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 If ONLY the correct numerical value is entered in the designated place;

Zero Marks : 0 In all other cases.

[Q.8] In an electrochemical cell, dichromate ions in aqueous acidic medium are reduced to Cr^{3+}. The current (in amperes) that flows through the cell for 48.25 minutes to produce 1 mole of Cr^{3+} is _____.

Use: 1 Faraday = 96500 C mol^{-1}

[ANS] **100**

[SOLN] $Cr_2O_7^{2-} \xrightarrow{H^+} Cr^{3+}$

1 mole

v.f = 3

Number of Equivalents = Number of Faraday

$$1\times 3 = \frac{I\times 48.25\times 60}{96500}$$

$$I = \frac{3\times 96500}{48.25\times 60} = 100$$

[Q.9] At 25 °C, the concentration of H^+ ions in 1.00×10^{-3} M aqueous solution of a weak monobasic acid having acid dissociation constant (K_a) of 4.00×10^{-11} is $\boldsymbol{X} \times 10^{-7}$ M. The value of $\boldsymbol{X}$ is _____.

Use: Ionic product of water (Kw) = 1.00×10^{-14} at 25 °C

[ANS] **2.24**

[SOLN] $[HA] = 1\times 10^{-3} M$

$ka = 4\times 10^{-11}$

$HA \rightleftharpoons H^+_{aq} + A^-$

10^{-3} O O

$10^{-3} - x$ $x + y$ x

$\approx 10^{-3}$

$$ka = \frac{\left[H^+\right]\left[A^-\right]}{[HA]}$$

$$4 \times 10^{-11} = \frac{(x+y)x}{10^{-3}}$$

$$4 \times 10^{-14} \simeq (x+y)x \qquad .....(1)$$

$H_2O \rightleftharpoons H^+ + OH^-$

Excers O O

$-y$ $y + x$ y

$$kw = \left[H^+\right]\left[OH^-\right]$$

$$10^{-14} = (x+y)y$$

$$10^{-14} = (x+y)y \qquad ....(2)$$

(1) + (2) $\Rightarrow 5 \times 10^{-14} \simeq (x+y)^2$

$$(x+y) = \sqrt{5} \times 10^{-7}$$

$$\left[H^+\right] = \sqrt{5} \times 10^{-7} = x \times 10^{-7}$$

$$x = \sqrt{5} = 2.236 = 2.24$$

[Q.10] Molar volume (V_m) of a van der Waals gas can be calculated by expressing the van der Waals equation as a cubic equation with V_m as the variable. The ratio (in mol dm^{-3}) of the coefficient of V_m^2 to the coefficient of V_m for a gas having van der Waals constants a = 6.0 dm^6 atm mol^{-2} and b = 0.060 dm^3 mol^{-1} at 300 K and 300 atm is _____.

Use: Universal gas constant (R) = 0.082 dm^3 atm mol^{-1} K^{-1}

[ANS] **-7.1**

[SOLN] $$\left(P + \frac{a}{Vm^2}\right)(V_m - b) = RT$$

$$PV_m - Pb + \frac{a}{V_m} - \frac{ab}{V_m^2} = RT$$

$$PV_m^3 - PbV_m^2 + aV_m - ab = RTV_m^2$$

$$PV_m^3 - (Pb + RT)V_m^2 + aV_m - ab = 0$$

$$V_m^3 - \left(b + \frac{RT}{P}\right)V_m^2 + \frac{a}{P}V_m - \frac{ab}{P} = 0$$

Coeff. of $V_m^2 = -\left(b + \frac{RT}{P}\right)$

Coeff. of $V_m = \frac{a}{P}$

$$= -\frac{\left(0.06 + \frac{0.082 \times 300}{300}\right)}{\frac{6}{300}}$$

$$= -\frac{(0.06 \times 300 + 0.082 \times 300)}{6}$$

$$= -\frac{(0.06 + 0.082)}{6} \times 300$$

$$= -\frac{(0.142)}{6} \times 300$$

$$= -\frac{14.2}{2} = -7.1$$

[Q.11] Considering ideal gas behavior, the expansion work done (in kJ) when 144 g of water is electrolyzed completely under constant pressure at 300 K is _____.

Use: Universal gas constant (R) = 8.3 J K^{-1} mol^{-1}; Atomic mass (in amu): H = 1, O = 16

[ANS] **29.88**

[SOLN]

$$\underset{8}{2H_2O(l)} \longrightarrow \underset{8}{2H_2(g)} + \underset{4}{O_2(g)}$$

$\Delta ny = 8 + 4 - 0 = 12$ ($\because$ H_2O is in liquid state)

$$w = -P_{ex}\Delta V$$

$$= -\Delta n_g RT$$

$$= -12 \times \frac{8.3}{1000} \times 300$$

$$= -12 \times 8.3 \times 0.3 = -29.88 \text{ KJ}$$

Magnitude of work done $= 29.88$ KJ

[Q.12] The monomer (X) involved in the synthesis of Nylon 6,6 gives positive carbylamine test. If 10 moles of X are analyzed using Dumas method, the amount (in grams) of nitrogen gas evolved is _____.

Use: Atomic mass of N (in amu) = 14

[ANS] **280**

[SOLN] Monomer of Nylon 6, 6

$NH_2-(CH_2)_6-NH_2+HOOC-(CH_2)_4-COOH$

Positive carbylamine test given by Primary amine

$NH_2-(CH_2)-NH_2 \xrightarrow{\text{Dumas method}} N_2$

10 mole

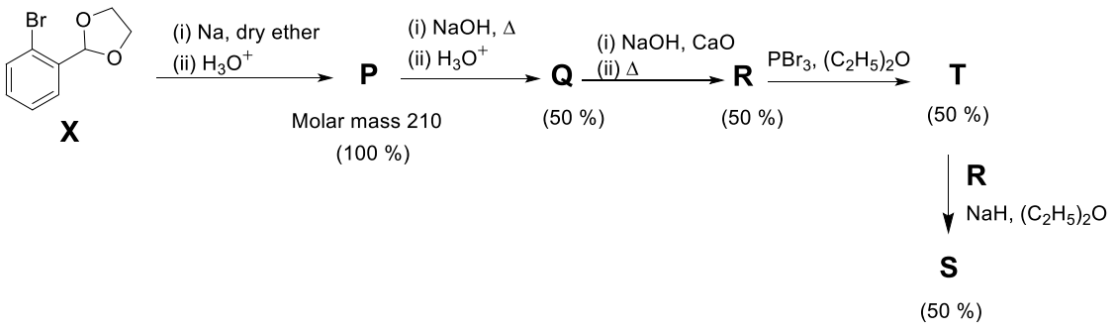
By POAC on N-atom

$2 \times \text{mole}_{\text{reactant}} = 2 \times \text{mole}_{N_2}$

$\text{mole}_{N_2} = 10$

$m_{N_2} = 10 \times 28 = 280\text{g}$

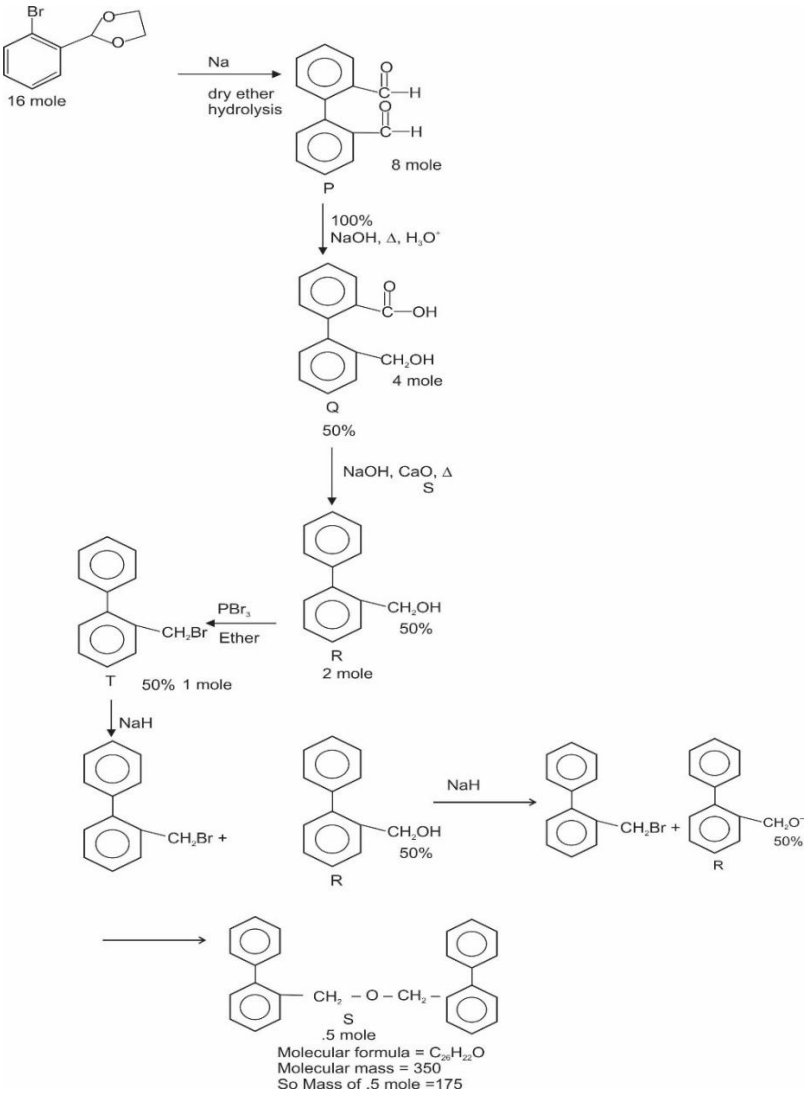
[Q.13] The reaction sequence given below is carried out with 16 moles of X. The yield of the major product in each step is given below the product in parentheses. The amount (in grams) of S produced is_____.



Use: Atomic mass (in amu): H = 1, C = 12, O = 16, Br = 80

[ANS] **175**

[SOLN]



SECTION 4 (Maximum Marks: 12)

- This section contains **THREE (03)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II.**
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**

  Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;

  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks : −1 In all other cases.

[Q.14] The correct match of the group reagents in List-I for precipitating the metal ion given in List-II from solutions, is

List-I	List-II
(P) Passing H_2S in the presence of NH_4OH	(1) Cu^{2+}
(Q) $(NH_4)_2CO_3$ in the presence of NH_4OH	(2) Al^{3+}
(R) NH_4OH in the presence of NH_4Cl	(3) Mn^{2+}
(S) Passing H_2S in the presence of dilute HCl	(4) Ba^{2+}
	(5) Mg^{2+}

[A] P → 3; Q → 4; R → 2; S → 1
[B] P → 4; Q → 2; R → 3; S → 1
[C] P → 3; Q → 4; R → 1; S → 5
[D] P → 5; Q → 3; R → 2; S → 4

[ANS] **A**

[SOLN]

Options

(p) Passing H_2S is presence of NH_4OH reagent of group-IV ⟶ Mn^{2+} (3)

(q) $(NH_4)_2CO_3$ in presence of NH_4OH reagent of group-V ⟶ Ba^{2+} (4)

(r) NH_4OH is presence of NH_4Cl reagent of group-III ⟶ Al^{3+} (2)

(s) Passing H_2S in presence of dil HCl – group-II ⟶ Cu^{2+} (1)

[Q.15] The major products obtained from the reactions in List-II are the reactants for the named reactions mentioned in List-I. Match each entry in List-I with the appropriate entry in List-II and choose the correct option.

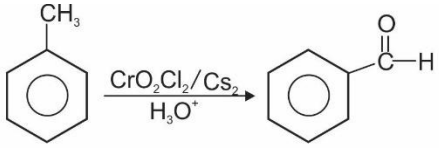
List-I	List-II
(P) Stephen reaction	(1) Toluene $\xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } CrO_2Cl_2/CS_2}$
(Q) Sandmeyer reaction	(2) Benzoic acid $\xrightarrow[\text{(iii) } P_4O_{10},\ \Delta]{\text{(i) } PCl_5,\ \text{(ii) } NH_3}$
(R) Hoffmann bromamide degradation reaction	(3) Nitrobenzene $\xrightarrow[\text{(273-278 K), } H_2O]{\text{(i) Fe, HCl, (ii) HCl, } NaNO_2}$
(S) Cannizzaro reaction	(4) Toluene $\xrightarrow[\text{(iii) } SO_2Cl_2,\ \text{(iv) } NH_3]{\text{(i) } Cl_2/h\nu,\ H_2O,\ \text{(ii) Tollen's reagent}}$
	(5) Aniline $\xrightarrow[\text{(ii) } HNO_3,\ H_2SO_4,\ 288\ K,\ \text{(iii) aq. NaOH}]{\text{(i) } (CH_3CO)_2O,\ \text{Pyridine}}$

[A] P → 2; Q → 4; R → 1; S → 3
[B] P → 2; Q → 3; R → 4; S → 1
[C] P → 5; Q → 3; R → 4; S → 2
[D] P → 5; Q → 4; R → 2; S → 1

[ANS] **B**

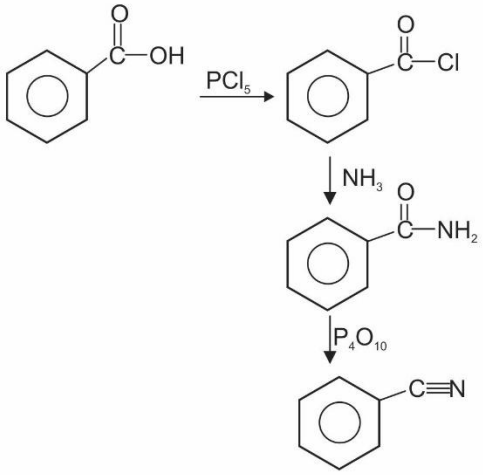
[SOLN]

(1)



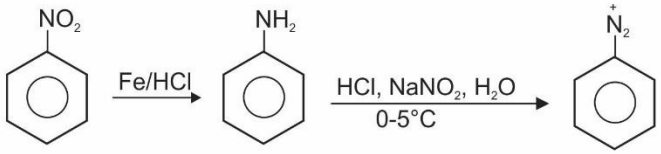
gives Cannizaro reaction

(2)



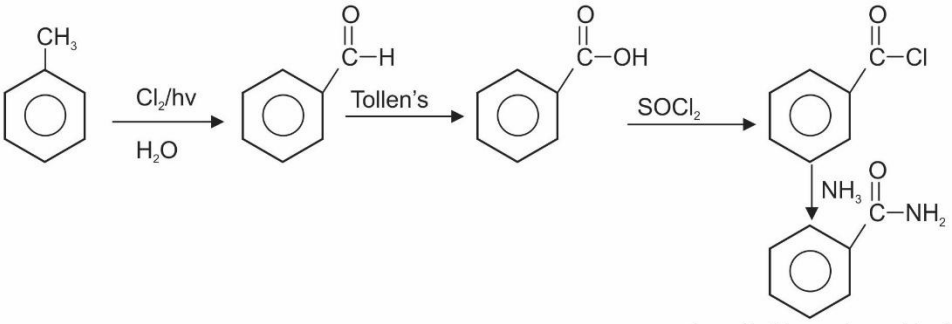
Stephen's reaction

(3)



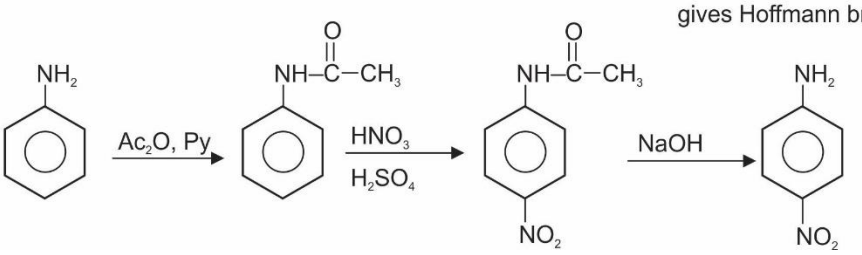
diazonium salt
gives sandmeyer reaction

(4)

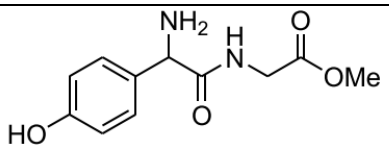
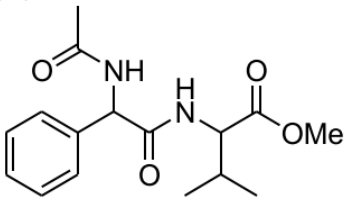
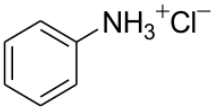
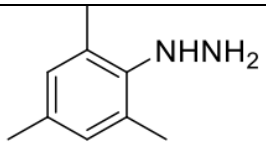


gives Hoffmann bromide degradation reaction

(5)



[Q.16] Match the compounds in List-I with the appropriate observations in List-II and choose the correct option.

	List-I		**List-II**
(P)		(1)	Reaction with phenyl diazonium salt gives yellow dye.
(Q)		(2)	Reaction with ninhydrin gives purple color and it also reacts with $FeCl_3$ to give violet color
(R)		(3)	Reaction with glucose will give corresponding hydrazone.
(S)		(4)	Lassiagne extract of the compound treated with dilute HCl followed by addition of aqueous $FeCl_3$ gives blood red color.
		(5)	After complete hydrolysis, it will give ninhydrin test and it DOES NOT give positive phthalein dye test.

[A] P → 1; Q → 5; R → 4; S → 2

[B] P → 2; Q → 5; R → 1; S → 3

[C] P → 5; Q → 2; R → 1; S → 4

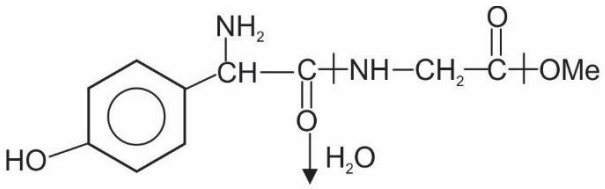
[D] P → 2; Q → 1; R → 5; S → 3

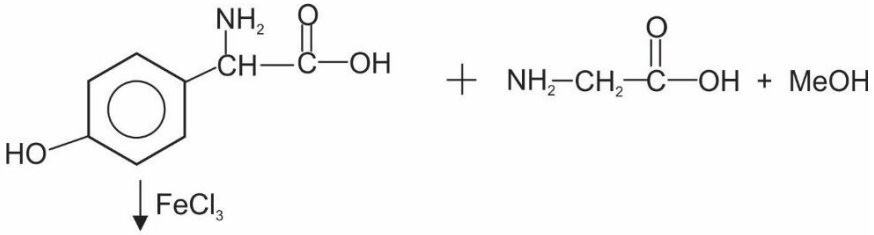
[ANS] **B**

[SOLN] i.e. P-2, Q-5, R-1, S-3

Reason

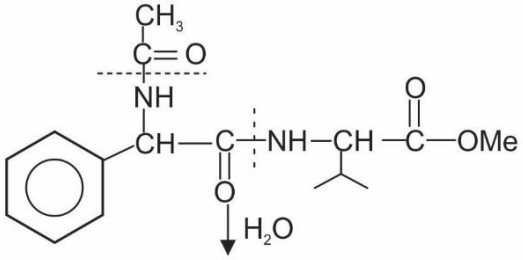
(P)

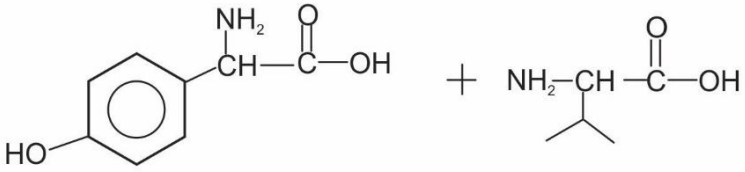


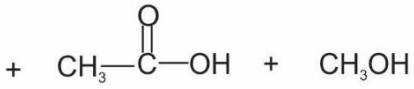


gives purple colour due to phenolic group

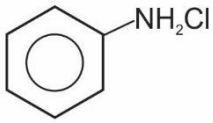
(Q)





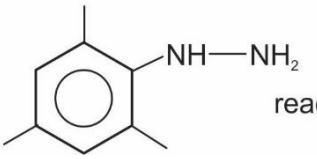


(R)



Cl react with diazonium and gives yellow dye.

(S)



react with Glucose gives phenyl hydrazone