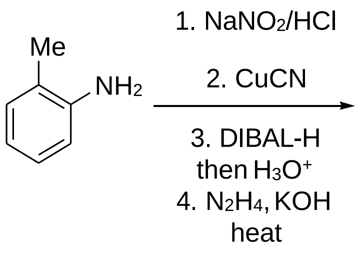
SECTION 1

- This section contains **SIX (06)** 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:

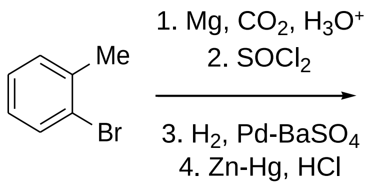
  Full Marks : +4 If only (all) the correct option(s) is(are) chosen;
  Partial Marks : +3 If all the four options are correct but ONLY three options are chosen;
  Partial Marks : +2 If three or more options are correct but ONLY two options are chosen, both of which are correct;
  Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option;
  Zero Marks : 0 If 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 +2marks;
  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(s) (i.e. the question is unanswered) will get 0 marks and
  choosing any other option(s) will get −2 marks.

Q.1 The reaction sequence(s) that would lead to *o*-xylene as the major product is(are)

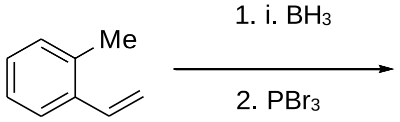
(A)



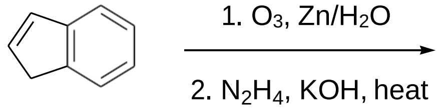
(B)



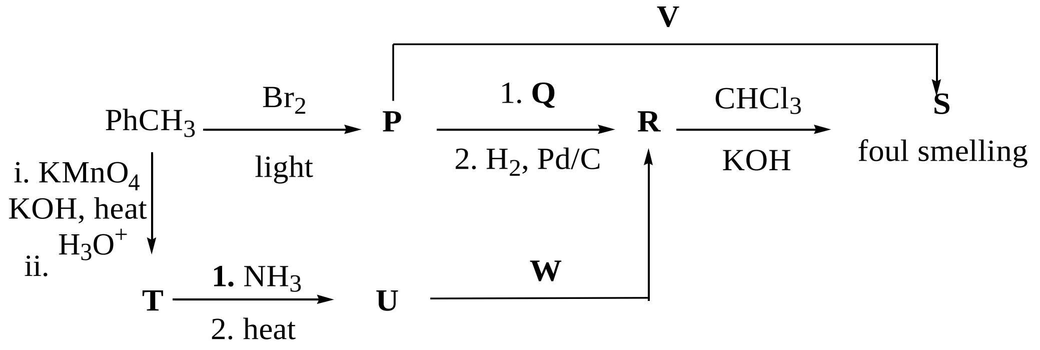
(C)



(D)



Q.2 Correct option(s) for the following sequence of reactions is(are)



(A) **Q** = KNO_2, **W** = $LiAlH_4$

(B) **R** = benzenamine, **V** = KCN

(C) **Q** = $AgNO_2$, **R** = phenylmethanamine

(D) **W** = $LiAlH_4$, **V** = AgCN

Q.3 For the following reaction

$2\mathbf{X} + \mathbf{Y} \xrightarrow{k} \mathbf{P}$

the rate of reaction is $\frac{d[\mathbf{P}]}{dt} = k[\mathbf{X}]$. Two moles of **X** are mixed with one mole of **Y** to make 1.0 L of solution. At 50 s, 0.5 mole of **Y** is left in the reaction mixture. The correct statement(s) about the reaction is(are)

(Use: ln 2 = 0.693)

(A) The rate constant, k, of the reaction is 13.86×10^{-4} s^{-1}.

(B) Half-life of **X** is 50 s.

(C) At 50 s, $-\frac{d[\mathbf{X}]}{dt} = 13.86 \times 10^{-3}$ mol L^{-1} s^{-1}.

(D) At 100 s, $-\frac{d[\mathbf{Y}]}{dt} = 3.46 \times 10^{-3}$ mol L^{-1} s^{-1}.

Q.4 Some standard electrode potentials at 298 K are given below:

Pb^{2+}/Pb	-0.13 V
Ni^{2+}/Ni	-0.24 V
Cd^{2+}/Cd	-0.40 V
Fe^{2+}/Fe	-0.44 V

To a solution containing 0.001 M of $\mathbf{X}^{2+}$ and 0.1 M of $\mathbf{Y}^{2+}$, the metal rods **X** and **Y** are inserted (at 298 K) and connected by a conducting wire. This resulted in dissolution of **X**. The correct combination(s) of **X** and **Y**, respectively, is(are)

(Given: Gas constant, R = 8.314 J K^{-1} mol^{-1},
Faraday constant, F = 96500 C mol^{-1})

(A) Cd and Ni

(B) Cd and Fe

(C) Ni and Pb

(D) Ni and Fe

Q.5 The pair(s) of complexes wherein both exhibit tetrahedral geometry is(are)

(Note: py = pyridine
Given: Atomic numbers of Fe, Co, Ni and Cu are 26, 27, 28 and 29, respectively)

(A) $[FeCl_4]^-$ and $[Fe(CO)_4]^{2-}$

(B) $[Co(CO)_4]^-$ and $[CoCl_4]^{2-}$

(C) $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$

(D) $[Cu(py)_4]^+$ and $[Cu(CN)_4]^{3-}$

Q.6 The correct statement(s) related to oxoacids of phosphorous is(are)

(A) Upon heating, H_3PO_3 undergoes disproportionation reaction to produce H_3PO_4 and PH_3.

(B) While H_3PO_3 can act as reducing agent, H_3PO_4 cannot.

(C) H_3PO_3 is a monobasic acid.

(D) The H atom of P–H bond in H_3PO_3 is not ionizable in water.

SECTION 2

- This section contains **THREE (03)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- 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 : +2 If ONLY the correct numerical value is entered at the designated place;
  Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 7 and 8

Question Stem

At 298 K, the limiting molar conductivity of a weak monobasic acid is 4×10^2 S cm^2 mol^{-1}. At 298 K, for an aqueous solution of the acid the degree of dissociation is α and the molar conductivity is $\mathbf{y} \times 10^2$ S cm^2 mol^{-1}. At 298 K, upon 20 times dilution with water, the molar conductivity of the solution becomes $3\mathbf{y} \times 10^2$ S cm^2 mol^{-1}.

Q.7 The value of α is____.

Q.8 The value of **y** is____.

Question Stem for Question Nos. 9 and 10

Question Stem

Reaction of **x** g of Sn with HCl quantitatively produced a salt. Entire amount of the salt reacted with **y** g of nitrobenzene in the presence of required amount of HCl to produce 1.29 g of an organic salt (quantitatively).

(Use Molar masses (in g mol^{-1}) of H, C, N, O, Cl and Sn as 1, 12, 14, 16, 35 and 119, respectively).

Q.9 The value of **x** is____.

Q.10 The value of **y** is____.

Question Stem for Question Nos. 11 and 12

Question Stem

A sample (5.6 g) containing iron is completely dissolved in cold dilute HCl to prepare a 250 mL of solution. Titration of 25.0 mL of this solution requires 12.5 mL of 0.03 M $KMnO_4$ solution to reach the end point. Number of moles of Fe^{2+} present in 250 mL solution is $\mathbf{x} \times 10^{-2}$ (consider complete dissolution of $FeCl_2$). The amount of iron present in the sample is **y**% by weight.

(Assume: $KMnO_4$ reacts only with Fe^{2+} in the solution
Use: Molar mass of iron as 56 g mol^{-1})

Q.11 The value of **x** is____.

Q.12 The value of **y** is____.

SECTION 3

- This section contains **TWO (02) paragraphs**. Based on each paragraph, there are **TWO (02)** 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.

Paragraph

The amount of energy required to break a bond is same as the amount of energy released when the same bond is formed. In gaseous state, the energy required for *homolytic cleavage* of a bond is called Bond Dissociation Energy (BDE) or Bond Strength. BDE is affected by *s*-character of the bond and the stability of the radicals formed. Shorter bonds are typically stronger bonds. BDEs for some bonds are given below:

$$H_3C{-}H(g) \longrightarrow H_3C^{\bullet}(g) + H^{\bullet}(g) \quad \Delta H^{o} = 105\ \text{kcal mol}^{-1}$$

$$Cl{-}Cl\,(g) \longrightarrow Cl^{\bullet}(g) + Cl^{\bullet}(g) \quad \Delta H^{o} = 58\ \text{kcal mol}^{-1}$$

$$H_3C{-}Cl(g) \longrightarrow H_3C^{\bullet}(g) + Cl^{\bullet}(g) \quad \Delta H^{o} = 85\ \text{kcal mol}^{-1}$$

$$H{-}Cl\,(g) \longrightarrow H^{\bullet}(g) + Cl^{\bullet}(g) \quad \Delta H^{o} = 103\ \text{kcal mol}^{-1}$$

Q.13 Correct match of the **C–H** bonds (shown in bold) in Column **J** with their BDE in Column **K** is

Column **J** Molecule	Column **K** BDE (kcal mol^{-1})
(P) **H–C**$H(CH_3)_2$	(i) 132
(Q) **H–C**H_2Ph	(ii) 110
(R) **H–C**$H{=}CH_2$	(iii) 95
(S) **H–C**$\equiv CH$	(iv) 88

(A) P – iii, Q – iv, R – ii, S – i

(B) P – i, Q – ii, R – iii, S – iv

(C) P – iii, Q – ii, R – i, S – iv

(D) P – ii, Q – i, R – iv, S – iii

Q.14 For the following reaction

$$CH_4(g) + Cl_2(g) \xrightarrow{\text{light}} CH_3Cl(g) + HCl(g)$$

the correct statement is

(A) Initiation step is exothermic with $\Delta H^o = -58$ kcal mol^{-1}.

(B) Propagation step involving $^{\bullet}CH_3$ formation is exothermic with $\Delta H^o = -2$ kcal mol^{-1}.

(C) Propagation step involving CH_3Cl formation is endothermic with $\Delta H^o = +27$ kcal mol^{-1}.

(D) The reaction is exothermic with $\Delta H^o = -25$ kcal mol^{-1}.

Paragraph

The reaction of $K_3[Fe(CN)_6]$ with freshly prepared $FeSO_4$ solution produces a dark blue precipitate called Turnbull's blue. Reaction of $K_4[Fe(CN)_6]$ with the $FeSO_4$ solution in complete absence of air produces a white precipitate **X**, which turns blue in air. Mixing the $FeSO_4$ solution with $NaNO_3$, followed by a slow addition of concentrated H_2SO_4 through the side of the test tube produces a brown ring.

Q.15 Precipitate **X** is

(A) $Fe_4[Fe(CN)_6]_3$ (B) $Fe[Fe(CN)_6]$

(C) $K_2Fe[Fe(CN)_6]$ (D) $KFe[Fe(CN)_6]$

Q.16 Among the following, the brown ring is due to the formation of

(A) $[Fe(NO)_2(SO_4)_2]^{2-}$ (B) $[Fe(NO)_2(H_2O)_4]^{3+}$

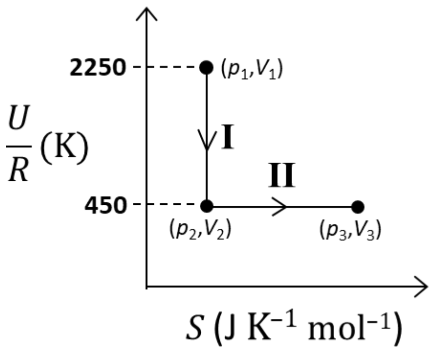
(C) $[Fe(NO)_4(SO_4)_2]$ (D) $[Fe(NO)(H_2O)_5]^{2+}$

SECTION 4

- This section contains **THREE (03)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER.**
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If ONLY the correct integer is entered;
Zero Marks : 0 In all other cases.

Q.17 One mole of an ideal gas at 900 K, undergoes two reversible processes, **I** followed by **II**, as shown below. If the work done by the gas in the two processes are same, the value of $\ln\frac{V_3}{V_2}$ is__.



(U: internal energy, S: entropy, p: pressure, V: volume, R: gas constant)

(Given: molar heat capacity at constant volume, $C_{V,m}$ of the gas is $\frac{5}{2}R$)

Q.18 Consider a helium (He) atom that absorbs a photon of wavelength 330 nm. The change in the velocity (in cm s^{-1}) of He atom after the photon absorption is____.

(Assume: Momentum is conserved when photon is absorbed.
Use: Planck constant = 6.6×10^{-34} J s, Avogadro number = 6×10^{23} mol^{-1}, Molar mass of He = 4 g mol^{-1})

Q.19 Ozonolysis of ClO_2 produces an oxide of chlorine. The average oxidation state of chlorine in this oxide is____.

END OF THE QUESTION PAPER