SECTION 1 (Maximum Marks: 24)

- This section contains **EIGHT (08)** 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 : +3 **ONLY** if the correct numerical value is entered;
Zero Marks : 0 In all other cases.

Q.1 2 mol of Hg(g) is combusted in a fixed volume bomb calorimeter with excess of O_2 at 298 K and 1 atm into HgO(s). During the reaction, temperature increases from 298.0 K to 312.8 K. If heat capacity of the bomb calorimeter and enthalpy of formation of Hg(g) are 20.00 kJ K^{-1} and 61.32 kJ mol^{-1} at 298 K, respectively, the calculated standard molar enthalpy of formation of HgO(s) at 298 K is X kJ mol^{-1}. The value of |X| is **90.39**. **Range (89.00-91.00)**

[Given: Gas constant R = 8.3 J K^{-1} mol^{-1}]

Q.2 The reduction potential (E^0, in V) of $MnO_4^-(aq)/Mn(s)$ is **0.77**. **Range (0.74-0.80)**

[Given: $E^0_{(MnO_4^-(aq)/MnO_2(s))}$ = 1.68 V; $E^0_{(MnO_2(s)/Mn^{2+}(aq))}$ = 1.21 V; $E^0_{(Mn^{2+}(aq)/Mn(s))}$ = −1.03 V]

Q.3 A solution is prepared by mixing 0.01 mol each of H_2CO_3, $NaHCO_3$, Na_2CO_3, and NaOH in 100 mL of water. *p*H of the resulting solution is _____. **10.02** **Range (10.00-10.04)**

[Given: pK_{a1} and pK_{a2} of H_2CO_3 are 6.37 and 10.32, respectively; log 2 = 0.30]

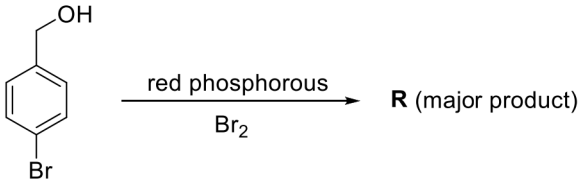
Q.4 The treatment of an aqueous solution of 3.74 g of $Cu(NO_3)_2$ with excess KI results in a brown solution along with the formation of a precipitate. Passing H_2S through this brown solution gives another precipitate **X**. The amount of **X** (in g) is _____. **0.32** **Range (0.31-0.33)**

[Given: Atomic mass of H = 1, N = 14, O = 16, S = 32, K = 39, Cu = 63, I = 127]

Q.5 Dissolving 1.24 g of white phosphorous in boiling NaOH solution in an inert atmosphere gives a gas **Q**. The amount of $CuSO_4$ (in g) required to completely consume the gas **Q** is _____. **2.39** **Range (2.37-2.41)**

[Given: Atomic mass of H = 1, O = 16, Na = 23, P = 31, S = 32, Cu = 63]

Q.6 Consider the following reaction.

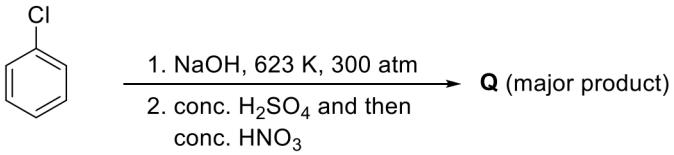


On estimation of bromine in 1.00 g of **R** using Carius method, the amount of AgBr formed (in g) is **1.50**. **Range (1.49-1.51)**

[Given: Atomic mass of H = 1, C = 12, O = 16, P = 31, Br = 80, Ag = 108]

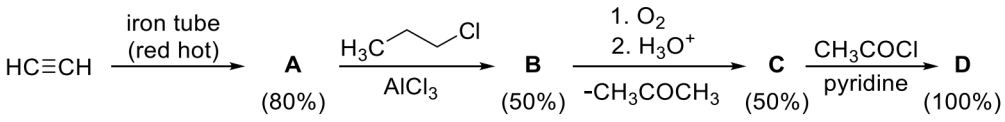
Q.7 The weight percentage of hydrogen in **Q**, formed in the following reaction sequence, is **1.31**.

Range (1.30-1.32)



[Given: Atomic mass of H = 1, C = 12, N = 14, O = 16, S = 32, Cl = 35]

Q.8 If the reaction sequence given below is carried out with 15 moles of acetylene, the amount of the product **D** formed (in g) is **136.00**. **Range (135.80-136.20)**



The yields of **A**, **B**, **C** and **D** are given in parentheses.
[Given: Atomic mass of H = 1, C = 12, O = 16, Cl = 35]

SECTION 2 (Maximum Marks: 24)

- 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	**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.

Q.9 For diatomic molecules, the correct statement(s) about the molecular orbitals formed by the overlap of two $2p_z$ orbitals is(are)

(A) σ orbital has a total of two nodal planes.
(B) σ^* orbital has one node in the xz-plane containing the molecular axis.
(C) π orbital has one node in the plane which is perpendicular to the molecular axis and goes through the center of the molecule.
(D) π^* orbital has one node in the xy-plane containing the molecular axis.

Answer: A, D

Q.10 The correct option(s) related to adsorption processes is(are)

(A) Chemisorption results in a unimolecular layer.
(B) The enthalpy change during physisorption is in the range of 100 to 140 kJ mol^{-1}.
(C) Chemisorption is an endothermic process.
(D) Lowering the temperature favors physisorption processes.

Answer: A, D

Q.11 The electrochemical extraction of aluminum from bauxite ore involves

(A) the reaction of Al_2O_3 with coke (C) at a temperature > 2500 ºC.
(B) the neutralization of aluminate solution by passing CO_2 gas to precipitate hydrated alumina ($Al_2O_3 \cdot 3H_2O$).
(C) the dissolution of Al_2O_3 in hot aqueous NaOH.
(D) the electrolysis of Al_2O_3 mixed with Na_3AlF_6 to give Al and CO_2.

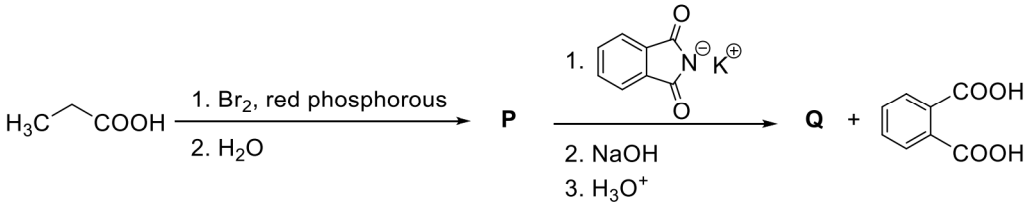
Answer: B, C, D

Q.12 The treatment of galena with HNO_3 produces a gas that is

(A) paramagnetic
(B) bent in geometry
(C) an acidic oxide
(D) colorless

Answer: A, D

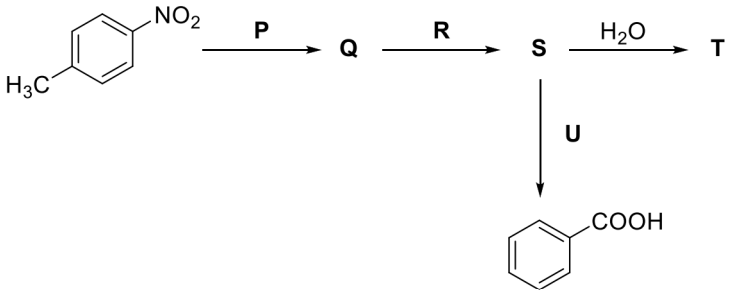
Q.13 Considering the reaction sequence given below, the correct statement(s) is(are)



(A) **P** can be reduced to a primary alcohol using $NaBH_4$.
(B) Treating **P** with conc. NH_4OH solution followed by acidification gives **Q**.
(C) Treating **Q** with a solution of $NaNO_2$ in aq. HCl liberates N_2.
(D) **P** is more acidic than CH_3CH_2COOH.

Answer: B, C, D

Q.14 Considering the following reaction sequence,

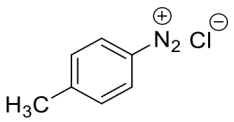


the correct option(s) is(are)

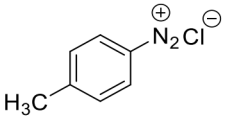
(A)

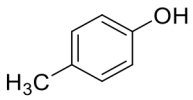
P = H_2/Pd, ethanol **R** = $NaNO_2$/HCl **U** = 1. H_3PO_2 2. $KMnO_4$ - KOH, heat

(B)

P = Sn/HCl **R** = HNO_2 **S** = 

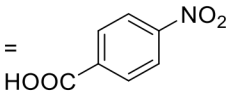
(C)

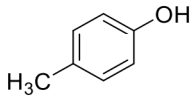
S = 

T = 

U = 1. CH_3CH_2OH 2. $KMnO_4$ - KOH, heat

(D)

Q = 

R = H_2/Pd, ethanol **T** = 

Answer: A, B, C

SECTION 3 (Maximum Marks: 12)

- This section contains **FOUR (04)** 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 (I), (II), (III) and (IV) and **List-II** has **Five** entries (P), (Q), (R), (S) and (T).
- **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 : $+3$ **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.15 Match the rate expressions in LIST-I for the decomposition of X with the corresponding profiles provided in LIST-II. X_s and k are constants having appropriate units.

LIST-I

(I)

$$\text{rate} = \frac{k[X]}{X_s + [X]}$$

under all possible initial concentrations of X

(II)

$$\text{rate} = \frac{k[X]}{X_s + [X]}$$

where initial concentrations of X are much less than X_s

(III)

$$\text{rate} = \frac{k[X]}{X_s + [X]}$$

where initial concentrations of X are much higher than X_s

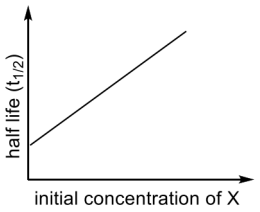
(IV)

$$\text{rate} = \frac{k[X]^2}{X_s + [X]}$$

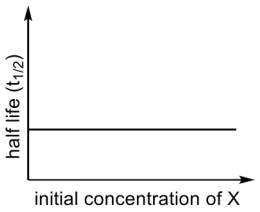
where initial concentration of X is much higher than X_s

LIST-II

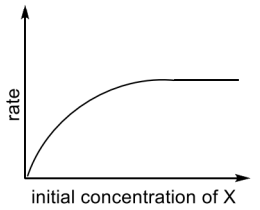
(P)



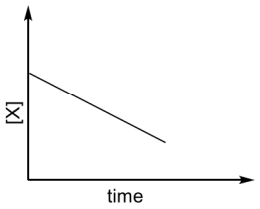
(Q)



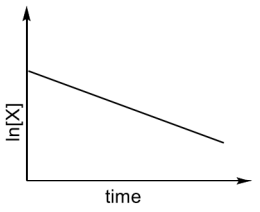
(R)



(S)



(T)



(A) I→ P; II→ Q; III → S; IV → T
(B) I→ R; II→ S; III → S; IV → T
(C) I→ P; II→ Q; III → Q; IV → R
(D) I→ R; II→ S; III → Q; IV → R

Answer: A

Q.16 LIST-I contains compounds and LIST-II contains reactions

LIST-I	LIST-II
(I) H_2O_2	(P) $Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow$
(II) $Mg(OH)_2$	(Q) $BaO_2 + H_2SO_4 \rightarrow$
(III) $BaCl_2$	(R) $Ca(OH)_2 + MgCl_2 \rightarrow$
(IV) $CaCO_3$	(S) $BaO_2 + HCl \rightarrow$
	(T) $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow$

Match each compound in LIST-I with its formation reaction(s) in LIST-II, and choose the correct option

(A) I → Q; II → P; III → S; IV → R
(B) I → T; II → P; III → Q; IV → R
(C) I → T; II → R; III → Q; IV → P
(D) I → Q; II → R; III → S; IV → P

Answer: D

Q.17 LIST-I contains metal species and LIST-II contains their properties.

LIST-I	LIST-II
(I) $[Cr(CN)_6]^{4-}$	(P) t_{2g} orbitals contain 4 electrons
(II) $[RuCl_6]^{2-}$	(Q) μ(spin-only) = 4.9 BM
(III) $[Cr(H_2O)_6]^{2+}$	(R) low spin complex ion
(IV) $[Fe(H_2O)_6]^{2+}$	(S) metal ion in 4+ oxidation state
	(T) d^4 species

[Given: Atomic number of Cr = 24, Ru = 44, Fe = 26]

Match each metal species in LIST-I with their properties in LIST-II, and choose the correct option

(A) I → R, T; II → P, S; III → Q, T; IV → P, Q
(B) I → R, S; II → P, T; III → P, Q; IV → Q, T
(C) I → P, R; II → R, S; III → R, T; IV → P, T
(D) I → Q, T; II → S, T; III → P, T; IV → Q, R

Answer: A

Q.18 Match the compounds in LIST-I with the observations in LIST-II, and choose the correct option.

LIST-I	LIST-II
(I) Aniline	(P) Sodium fusion extract of the compound on boiling with $FeSO_4$, followed by acidification with conc. H_2SO_4, gives Prussian blue color.
(II) *o*-Cresol	(Q) Sodium fusion extract of the compound on treatment with sodium nitroprusside gives blood red color.
(III) Cysteine	(R) Addition of the compound to a saturated solution of $NaHCO_3$ results in effervescence.
(IV) Caprolactam	(S) The compound reacts with bromine water to give a white precipitate.
	(T) Treating the compound with neutral $FeCl_3$ solution produces violet color.

(A) I→P,Q; II→S; III→Q,R; IV→P
(B) I→P; II→R,S; III→R; IV→Q,S
(C) I→Q,S; II→P,T; III→P; IV→S
(D) I→P,S; II→T; III→Q,R; IV→P

Answer: D

END OF THE QUESTION PAPER