**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 A closed vessel contains 10 g of an ideal gas **X** at 300 K, which exerts 2 atm pressure. At the same temperature, 80 g of another ideal gas **Y** is added to it and the pressure becomes 6 atm. The ratio of root mean square velocities of **X** and **Y** at 300 K is

(A) $2\sqrt{2} : \sqrt{3}$ (B) $2\sqrt{2} : 1$ (C) $1 : 2$ (D) $2 : 1$

**Answer: (D)**

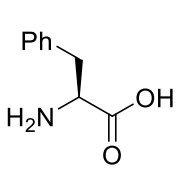
Q.2 At room temperature, disproportionation of an aqueous solution of *in situ* generated nitrous acid ($HNO_2$) gives the species

(A) $H_3O^+$, $NO_3^-$ and NO
(B) $H_3O^+$, $NO_3^-$ and $NO_2$
(C) $H_3O^+$, $NO^-$ and $NO_2$
(D) $H_3O^+$, $NO_3^-$ and $N_2O$

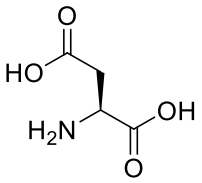
**Answer: (A)**

Q.3 Aspartame, an artificial sweetener, is a dipeptide aspartyl phenylalanine methyl ester. The structure of aspartame is

Structures of phenylalanine and aspartic acid are given below.

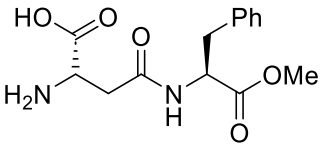



Phenylalanine

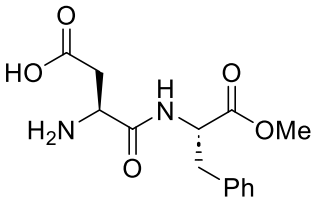



Aspartic acid

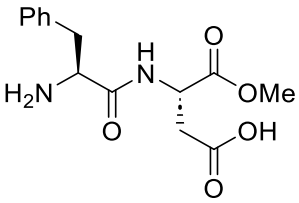
(A)



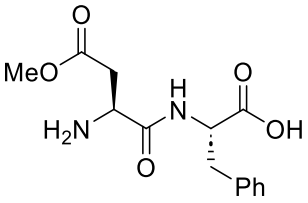

(B)




(C)




(D)




**Answer: (B)**

Q.4 Among the following options, select the option in which each complex in **Set-I** shows geometrical isomerism and the two complexes in **Set-II** are ionization isomers of each other.

[en = $H_2NCH_2CH_2NH_2$]

(A) **Set-I**: $[Ni(CO)_4]$ and $[PdCl_2(PPh_3)_2]$
**Set-II**: $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5(SO_4)]Cl$

(B) **Set-I**: $[Co(en)(NH_3)_2Cl_2]$ and $[PdCl_2(PPh_3)_2]$
**Set-II**: $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$

(C) **Set-I**: $[Co(NH_3)_3(NO_2)_3]$ and $[Co(en)_2Cl_2]$
**Set-II**: $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5(SO_4)]Cl$

(D) **Set-I**: $[Cr(NH_3)_5Cl]Cl_2$ and $[Co(en)(NH_3)_2Cl_2]$
**Set-II**: $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

**Answer: (C)**

**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 <u>according to the following marking scheme</u>:

  *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 Among the following, the correct statement(s) for electrons in an atom is(are)

(A) Uncertainty principle rules out the existence of definite paths for electrons.

(B) The energy of an electron in 2*s* orbital of an atom is lower than the energy of an electron that is infinitely far away from the nucleus.

(C) According to Bohr's model, the most negative energy value for an electron is given by n = 1, which corresponds to the most stable orbit.

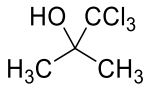
(D) According to Bohr's model, the magnitude of velocity of electrons increases with increase in values of n.

**Answer: (A), (B), (C)**

Q.6 Reaction of *iso*-propylbenzene with $O_2$ followed by the treatment with $H_3O^+$ forms phenol and a by-product **P**. Reaction of **P** with 3 equivalents of $Cl_2$ gives compound **Q**. Treatment of **Q** with $Ca(OH)_2$ produces compound **R** and calcium salt **S**.

The correct statement(s) regarding **P**, **Q**, **R** and **S** is(are)

(A) Reaction of **P** with **R** in the presence of KOH followed by acidification gives




(B) Reaction of **R** with $O_2$ in the presence of light gives phosgene gas

(C) **Q** reacts with aqueous NaOH to produce $Cl_3CCH_2OH$ and $Cl_3CCOONa$

(D) **S** on heating gives **P**

**Answer: (A), (B), (D)**

Q.7 The option(s) in which at least three molecules follow Octet Rule is(are)

(A) $CO_2$, $C_2H_4$, NO and HCl

(B) $NO_2$, $O_3$, HCl and $H_2SO_4$

(C) $BCl_3$, NO, $NO_2$ and $H_2SO_4$

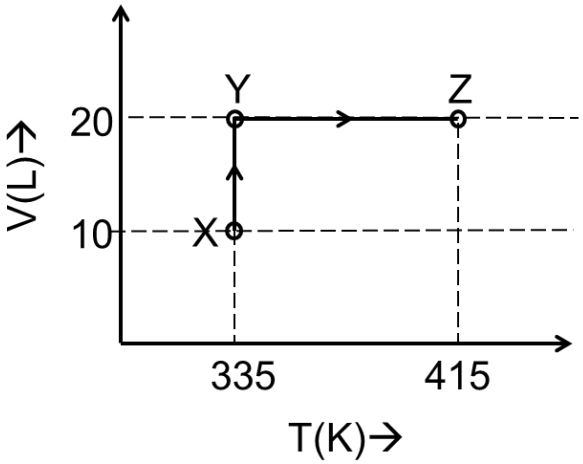
(D) $CO_2$, $BCl_3$, $O_3$ and $C_2H_4$

**Answer: (A), (D)**

**SECTION 3 (Maximum Marks: 24)**

- This section contains **SIX (06)** 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.8 Consider the following volume–temperature (V–T) diagram for the expansion of 5 moles of an ideal monoatomic gas.




Considering only P-V work is involved, the total change in enthalpy (in Joule) for the transformation of state in the sequence **X→Y→Z** is _____.

[Use the given data: Molar heat capacity of the gas for the given temperature range, $C_{V,m} = 12$ J $K^{-1}$ $mol^{-1}$ and gas constant, R = 8.3 J $K^{-1}$ $mol^{-1}$]

**Answer: 8000 OR 8120 OR 8300**

Q.9 Consider the following reaction,

$$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$$

which follows the mechanism given below:

$$2NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2(g) \qquad \text{(fast equlibrium)}$$

$$N_2O_2(g) + H_2(g) \xrightarrow{k_2} N_2O(g) + H_2O(g) \qquad \text{(slow reaction)}$$

$$N_2O(g) + H_2(g) \xrightarrow{k_3} N_2(g) + H_2O(g) \qquad \text{(fast reaction)}$$

The order of the reaction is _____.

**Answer: 3**

Q.10 Complete reaction of acetaldehyde with excess formaldehyde, upon heating with conc. NaOH solution, gives **P** and **Q**. Compound **P** does not give Tollens' test, whereas **Q** on acidification gives positive Tollens' test. Treatment of **P** with excess cyclohexanone in the presence of catalytic amount of *p*-toluenesulfonic acid (PTSA) gives product **R**.

Sum of the number of methylene groups (-$CH_2$-) and oxygen atoms in **R** is _____.

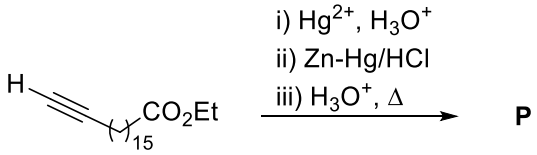
**Answer: 18**

Q.11 Among $V(CO)_6$, $Cr(CO)_5$, $Cu(CO)_3$, $Mn(CO)_5$, $Fe(CO)_5$, $[Co(CO)_3]^{3-}$, $[Cr(CO)_4]^{4-}$, and $Ir(CO)_3$, the total number of species isoelectronic with $Ni(CO)_4$ is _____.

[Given, atomic number: V = 23, Cr = 24, Mn = 25, Fe = 26, Co = 27, Ni = 28, Cu = 29, Ir = 77]

**Answer: 3**

Q.12 In the following reaction sequence, the major product **P** is formed.




Glycerol reacts completely with excess **P** in the presence of an acid catalyst to form **Q**. Reaction of **Q** with excess NaOH followed by the treatment with $CaCl_2$ yields Ca-soap **R**, quantitatively. Starting with one mole of **Q**, the amount of **R** produced in gram is _____.

[Given, atomic weight: H = 1, C = 12, N = 14, O = 16, Na = 23, Cl = 35, Ca = 40]

**Answer: 909**

Q.13 Among the following complexes, the total number of diamagnetic species is _____.

$[Mn(NH_3)_6]^{3+}$, $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$, $[CoF_6]^{3-}$, $[Fe(NH_3)_6]^{3+}$, and $[Co(en)_3]^{3+}$

[Given, atomic number: Mn = 25, Fe = 26, Co = 27;

en = $H_2NCH_2CH_2NH_2$]

**Answer: 1**

**SECTION 4 (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 (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 <u>according to the following marking scheme</u>:

  *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.14 In a conductometric titration, small volume of titrant of higher concentration is added stepwise to a larger volume of titrate of much lower concentration, and the conductance is measured after each addition.

The limiting ionic conductivity ($\Lambda_0$) values (in mS $m^2$ $mol^{-1}$) for different ions in aqueous solutions are given below:

| Ions | $Ag^+$ | $K^+$ | $Na^+$ | $H^+$ | $NO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $OH^-$ | $CH_3COO^-$ |
|---|---|---|---|---|---|---|---|---|---|
| $\Lambda_0$ | 6.2 | 7.4 | 5.0 | 35.0 | 7.2 | 7.6 | 16.0 | 19.9 | 4.1 |

For different combinations of titrates and titrants given in **List-I**, the graphs of 'conductance' versus 'volume of titrant' are given in **List-II**.

Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

**List-I**

(P) Titrate: KCl
Titrant: $AgNO_3$

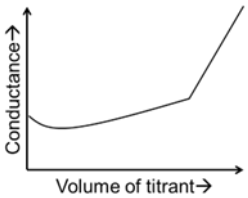
(Q) Titrate: $AgNO_3$
Titrant: KCl

(R) Titrate: NaOH
Titrant: HCl

(S) Titrate: NaOH
Titrant: $CH_3COOH$

**List-II**

(1)

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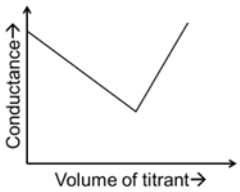


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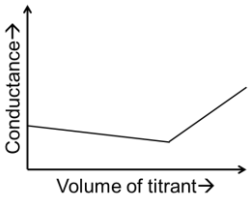


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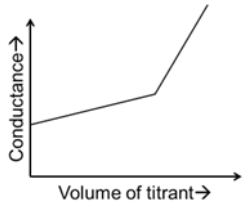


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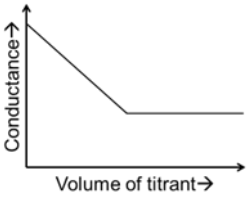



(A) P-4, Q-3, R-2, S-5

(B) P-2, Q-4, R-3, S-1

(C) P-3, Q-4, R-2, S-5

(D) P-4, Q-3, R-2, S-1

**Answer: (C)**

Q.15 Based on **VSEPR** model, match the xenon compounds given in **List-I** with the corresponding geometries and the number of lone pairs on xenon given in **List-II** and choose the correct option.

| **List-I** | **List-II** |
|---|---|
| (P) $XeF_2$ | (1) Trigonal bipyramidal and two lone pair of electrons |
| (Q) $XeF_4$ | (2) Tetrahedral and one lone pair of electrons |
| (R) $XeO_3$ | (3) Octahedral and two lone pair of electrons |
| (S) $XeO_3F_2$ | (4) Trigonal bipyramidal and no lone pair of electrons |
| | (5) Trigonal bipyramidal and three lone pair of electrons |

(A) P-5, Q-2, R-3, S-1

(B) P-5, Q-3, R-2, S-4

(C) P-4, Q-3, R-2, S-1

(D) P-4, Q-2, R-5, S-3

**Answer: (B)**

Q.16 **List-I** contains various reaction sequences and **List-II** contains the possible products. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

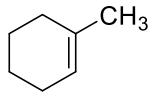
**List-I**

(P)

i) $O_3$, Zn
ii) aq. NaOH, Δ
iii) ethylene glycol, PTSA

iv) a) $BH_3$, b) $H_2O_2$, NaOH
v) $H_3O^+$
vi) $NaBH_4$

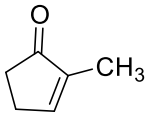
(Q)



i) $O_3$, Zn
ii) aq. NaOH, Δ

iii) ethylene glycol, PTSA
iv) a) $BH_3$, b) $H_2O_2$, NaOH
v) $H_3O^+$
vi) $NaBH_4$

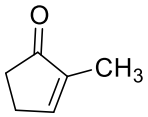
(R)



i) ethylene glycol, PTSA

ii) a) $Hg(OAc)_2$, $H_2O$, b) $NaBH_4$
iii) $H_3O^+$
iv) $NaBH_4$

(S)

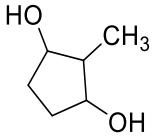


i) ethylene glycol, PTSA

ii) a) $BH_3$, b) $H_2O_2$, NaOH
iii) $H_3O^+$
iv) $NaBH_4$

**List-II**

(1)



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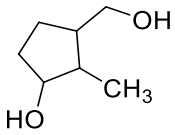

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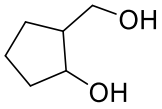

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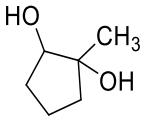

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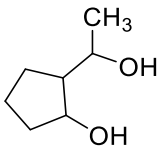


(A) P-3, Q-5, R-4, S-1

(B) P-3, Q-2, R-4, S-1

(C) P-3, Q-5, R-1, S-4

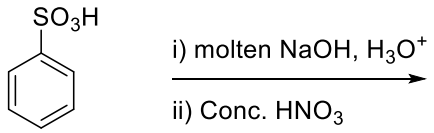
(D) P-5, Q-2, R-4, S-1

**Answer: (A)**

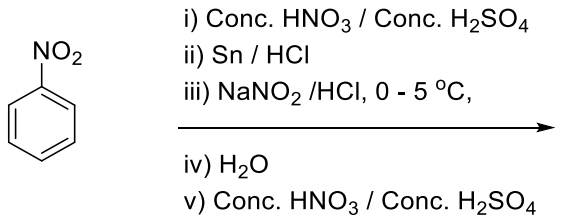
Q.17 **List-I** contains various reaction sequences and **List-II** contains different phenolic compounds. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

**List-I**

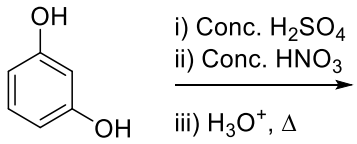
(P)



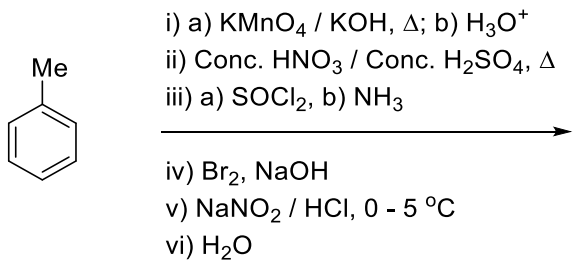

(Q)




(R)

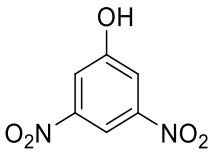



(S)




**List-II**

(1)

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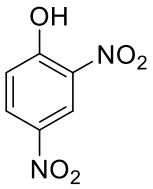
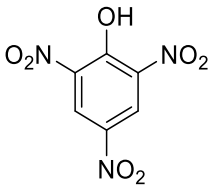
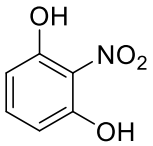


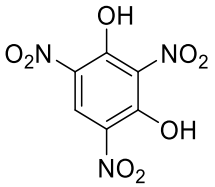

(3)




(4)




(5)




(A) P-2, Q-3, R-4, S-5

(B) P-2, Q-3, R-5, S-1

(C) P-3, Q-5, R-4, S-1

(D) P-3, Q-2, R-5, S-4

**Answer: (C)**

## END OF THE QUESTION PAPER