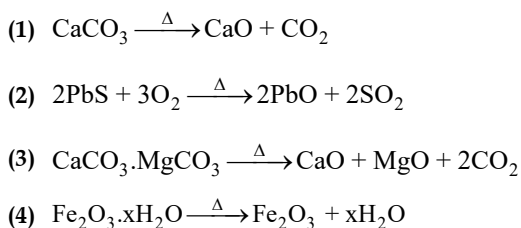


JEE (Main) CHEMISTRY SOLVED PAPER

2023
15th April Shift 1

Section A

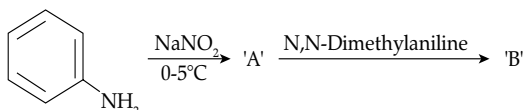
1. Which one of the following is not an example of calcination?



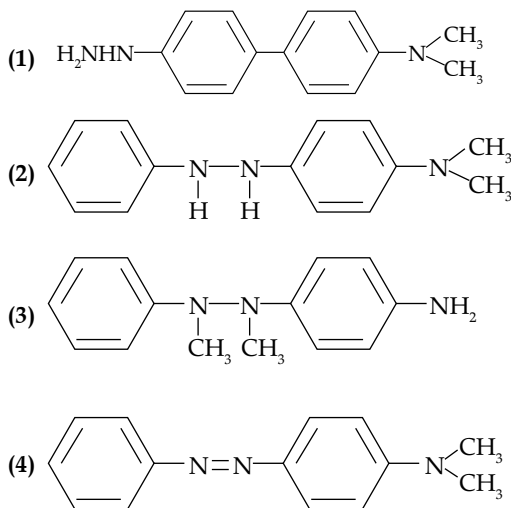
2. During water-gas shift reaction

- (1) Water is evaporated in presence of catalyst.
 (2) Carbon monoxide is oxidized to carbon dioxide
 (3) Carbon is oxidized to carbon monoxide.
 (4) Carbon dioxide is reduced to carbon monoxide.

3. Consider the following sequence of reaction:



The product 'B' is :



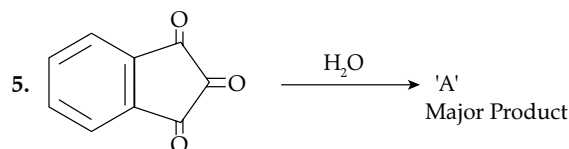
4. Given below are two statements: One is labeled as Assertion A and the other is labelled as Reason R:
Assertion (A): BeCl_2 and MgCl_2 Produce characteristic flame
Reason (R): The excitation energy is high in BeCl_2 and MgCl_2

In the light of the above statement, choose the correct answer from the options given below:

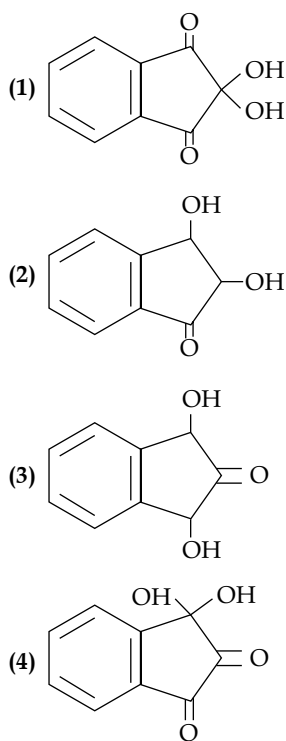
- (1) (A) is False but (R) is true
 (2) Both (A) and (R) are true and (R) is the correct explanation of (A)

- (3) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

- (4) (A) is true but (R) is false



'A' formed in the above reaction is :



6. For a good quality cement, the ratio of silica to alumina is found to be

- (1) 2 (2) 3 (3) 4.5 (4) 1.5

7. Which of the following expressions is correct in case of a CaCl unit cell (edge length 'a')?

(1) $r_{\text{Ca}^{2+}} + r_{\text{Cl}^{-}} = \frac{a}{\sqrt{2}}$ (2) $r_{\text{Ca}^{2+}} + r_{\text{Cl}^{-}} = a$

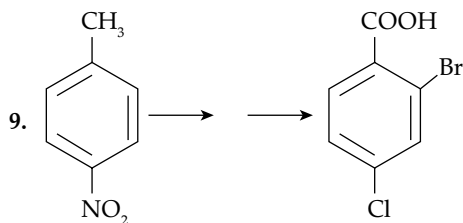
(3) $r_{\text{Ca}^{2+}} + r_{\text{Cl}^{-}} = \frac{\sqrt{3}}{2}a$ (4) $r_{\text{Ca}^{2+}} + r_{\text{Cl}^{-}} = \frac{a}{2}$

8. Given below are two statements

Statement I: According to Bohr's model of hydrogen atom, the angular momentum of an electron in a given stationary state is quantised.

Statement II: The concept of electron in Bohr's orbit violates the Heisenberg uncertainty principle. In the light of the above statements, choose the most appropriate answer from the options given below

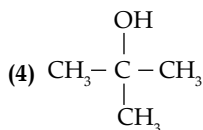
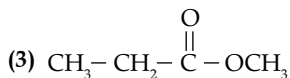
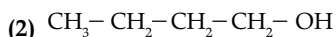
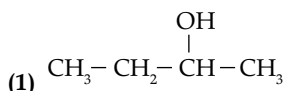
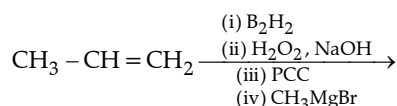
- (1) Statement I is correct but Statement II is incorrect
- (2) Both Statement I and Statement II are incorrect
- (3) Statement I is incorrect but Statement II is correct
- (4) Both Statement I and Statement II are correct



In the above conversion the correct sequence of reagents to be added is :

Options:

- (1) (i) Br_2/Fe , (ii) Fe/H^+ , (iii) KMnO_4 , (iv) Cl_2
 - (2) (i) Br_2/Fe , (ii) Fe/H^+ , (iii) HONO , (iv) CuCl , (v) KMnO_4
 - (3) (i) Fe/H^+ , (ii) HONO , (iii) CuCl , (iv) KMnO_4 , (v) Br_2
 - (4) (i) KMnO_4 , (ii) Br_2/Fe , (iii) Fe/H^+ , (iv) Cl_2
10. The product formed in the following multistep reaction is:



11. The possibility of photochemical smog formation will be minimum at
- (1) Srinagar, Jammu and Kashmir in January
 - (2) New-Delhi in August (summer)
 - (3) Kolkata in October
 - (4) Mumbai in May
12. Consider the following statements:
- (A) NF_3 molecule has a trigonal planar structure.
 - (B) Bond length of N_2 is shorter than O_2

- (C) Isoelectronic molecules or ions have identical bond order
- (D) Dipole moment of HS is higher than that of water molecule.

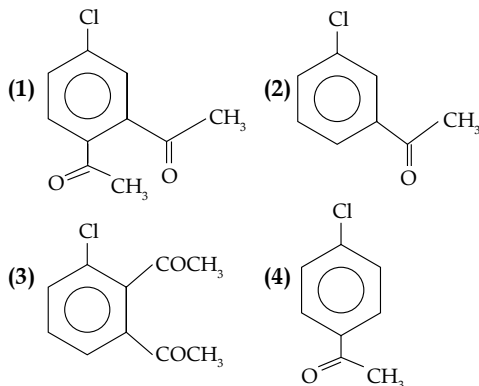
Choose the correct answer from the options given below:

- (1) (A) and (B) are correct
 - (2) (C) and (D) are correct
 - (3) (B) and (C) are correct
 - (4) (A) and (D) are correct
13. The number of P-O-P bonds in $\text{H}_4\text{P}_2\text{O}_7$, $(\text{HPO}_3)_3$, and P_4O_{10} are respectively
- (1) 1, 3, 6
 - (2) 0, 3, 6
 - (3) 0, 3, 4
 - (4) 1, 2, 4
14. Which is not true for arginine?
- (1) It has high solubility in benzene
 - (2) It is associated with more than one pK_a values.
 - (3) It is a crystalline solid.
 - (4) It has a fairly high melting point.
15. The complex with highest magnitude of crystal field splitting energy (Δ_0) is
- (1) $[\text{Mn}(\text{OH}_2)_6]^{3+}$
 - (2) $[\text{Fe}(\text{OH}_2)_6]^{3+}$
 - (3) $[\text{Cr}(\text{OH}_2)_6]^{3+}$
 - (4) $[\text{Ti}(\text{OH}_2)_6]^{3+}$
16. Which of the following statement is correct for paper chromatography?
- (1) Water present in the pores of the paper forms the stationary phase.
 - (2) Water present in the mobile phase gets absorbed by the paper which then forms the stationary phase
 - (3) Paper sheet forms the stationary phase.
 - (4) Paper and water present in its pores together form the stationary phase.
17. Which of the following statement(s) is/are correct?
- (A) The pH of 1×10^{-8} M HCl solution is 8
 - (B) The conjugate base of H_2PO_4^- is HPO_4^{2-}
 - (C) K_w increases with increase in temperature
 - (D) When a solution of a weak monoprotic acid is titrated against a strong base at half neutralisation point.

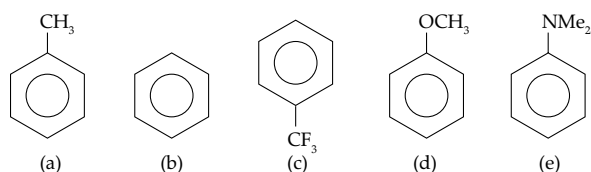
$$\text{pH} = \frac{1}{2} \text{pK}_a$$

Choose the correct answer from the options given below

- (1) (A), (B), (C)
 - (2) (A), (D)
 - (3) (B), (C)
 - (4) (B), (C), (D)
18. The major product in the Friedel-Craft acylation of chlorobenzene is:



19. Decreasing order of reactivity towards electrophilic substitution for the following compounds is:



- (1) $a > d > e > b > c$ (2) $c > b > a > d > e$
 (3) $e > d > a > b > c$ (4) $d > a > e > c > b$

20. Match List-I with List-II:

List-I (Monomer)

- (A) Tetrafluoroethene
 (B) Acrylonitrile
 (C) Caprolactam
 (D) Isoprene

List-II (Polymer)

- (I) Orlon
 (II) Natural rubber
 (III) Teflon
 (IV) Nylon-6

Choose the correct answer from the options given below:

- (1) (A)-(II), (B)-(III), (C)-(IV), (D)-(I)
 (2) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)
 (3) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)
 (4) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

Section B

21. The homoleptic and octahedral complex of Co^{2+} and H_2O has _____ unpaired electron(s) in the t_{2g} set of orbitals.
22. 30.4 kJ of heat is required to melt one mole of sodium chloride and the entropy change at the melting point is $28.4 \text{ J K}^{-1} \text{ mol}^{-1}$ at 1 atm. The melting point of sodium chloride is _____ K. (Nearest Integer)
23. The total number of isoelectronic species from the given set is _____.
 $\text{O}^{2-}, \text{F}^-, \text{Al}, \text{Mg}^{2+}, \text{Na}^+, \text{O}^+, \text{Mg}, \text{Al}^{3+}, \text{F}$
24. For a reversible reaction $\text{A} \rightleftharpoons \text{B}$, the $\Delta H_{\text{forward reaction}} = 20 \text{ kJ mol}^{-1}$. The activation energy

of the uncatalysed forward reaction is 300 kJ mol^{-1} . When the reaction is catalysed keeping the reactant concentration same, the rate of the catalysed forward reaction at 27°C is found to be same as that of the uncatalysed reaction at 327°C . The activation energy of the catalysed backward reaction is _____ kJ mol^{-1} .

25. The vapour pressure of 30% (w/v) aqueous solution of glucose is _____ mm Hg at 25°C .
 [Given: The density of 30% (w/v), aqueous solutions of glucose is 1.2 g cm^{-3} and vapour pressure of pure water is 24 mm Hg.]
 (Molar mass of glucose is 180 g mol^{-1})
26. In Chromyl chloride, the oxidation state of chromium is (+) _____.
27. The volume (in mL) of 0.1 M AgNO_3 required for complete precipitation of chloride ions present in 20 mL of 0.01 M solution of $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$ as silver chloride is _____.
28. 20 mL of 0.5 M NaCl is required to coagulate 200 mL, of As_2S_3 solution in 2 hours. The coagulating value of NaCl is _____.
29. The total change in the oxidation state of manganese involved in the reaction of KMnO_4 and potassium iodide in the acidic medium is _____.
30. The number of correct statements from the following is _____.
- (A) Conductivity always decreases with decrease in concentration for both strong and weak electrolysis.
 (B) The number of ions per unit volume that carry current in a solution increases on dilution.
 (C) Molar conductivity increases with decrease in concentration.
 (D) The variation in molar conductivity is different for strong and weak electrolysis.
 (E) For weak electrolysis, the change in molar conductivity with dilution is due to decrease in degree of dissociation.

Answer Key

Q. No.	Answer	Topic name	Chapter name
1	(2)	Calcination Process	Metallurgy
2	(2)	Water gas shift reaction	Hydrogen
3	(4)	Nucleophilic Aromatic Substitution Reaction	Amines
4	(1)	Characteristics colour of flame	s Block
5	(1)	Nucleophilic Addition Reaction	Aldehyde and Ketones
6	(2)	Ratio of compounds in cement	p Block
7	(3)	Calculation of Edge Length	Solid State
8	(4)	Bohr Atomic Model	Structure of Atom
9	(4)	Organic conversion in aromatic hydrocarbons	Aromatic Hydrocarbons
10	(1)	Multiple Reaction of Alkene	Hydrocarbon
11	(1)	Photochemical Smog	Environmental Chemistry
12	(3)	Bond Parameters	Chemical Bonding
13	(1)	Calculation of Number of Bonds	Chemical Bonding

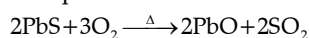
14	(1)	Properties of Amino Acid	Biomolecules
15	(3)	CFSE Value Calculation	Coordination Chemistry
16	(1)	Paper Chromatography	General Organic Chemistry
17	(1)	Mixed concept on various theories of acid and base	Ionic Equilibrium
18	(4)	Friedel Craft Acylation	Aromatic Hydrocarbons
19	(3)	Electrophilic aromatic substitution	Aromatic Hydrocarbons
20	(2)	Different Monomers	Polymer
21	[1]	CFSE	Coordination Compounds
22	[1070]	Calculation of melting point	Thermodynamics
23	[5]	Isoelectronic species	Periodic Classification
24	[130]	Calculation of activation energy	Chemical Kinetics
25	[23]	Calculation of vapour pressure	Liquid Solution
26	[6]	Oxidation state calculation	Redox Reaction
27	[4]	Volumetric Analysis	Some Basic Concepts of Chemistry
28	[50]	Coagulation value	Surface Chemistry
29	[5]	Change in oxidation state during Redox Reaction	Redox Reaction
30	[3]	Mixed Concept on conductivity	Electro Chemistry

Solutions

Section A

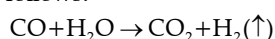
1. **Option (2) is correct.**

Calcination is the process which permit process. when the volatile matter escapes leaving behind the metal oxide. This process takes place in the absence or limited supply of air or oxygen. Among the given example, the one which is not an example of calcination is

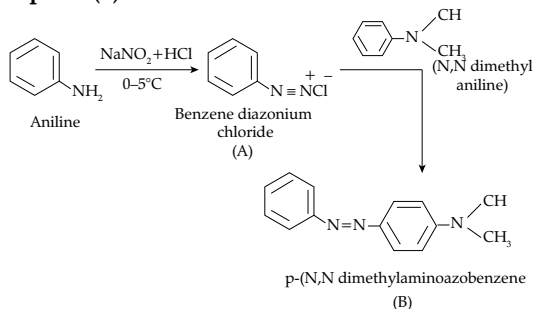


2. **Option (2) is correct.**

During water-gas shift reaction, carbon monoxide is oxidized to carbon dioxide. The reaction is as follows:



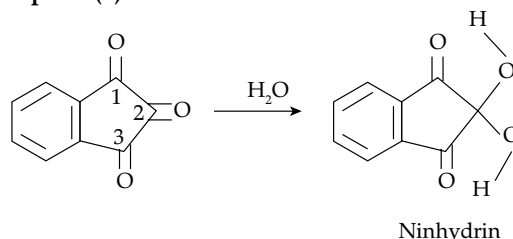
3. **Option (4) is correct.**



4. **Option (1) is correct.**

Be^{2+} and Mg^{2+} do not undergo transition and hence don't impart characteristic colour to the flame. Be and Mg have small size when compared to the other alkali metals. Due to this they have high ionization energy (excitation energy)

5. **Option (1) is correct.**



The marked carbon (1 and 3) will not add water as they both are in conjugation with benzene ring. The Ninhydrin structure thus formed will not undergo dehydration as it gets stabilized by intramolecular H-bonding.

6. **Option (2) is correct.**

For a good quality cement, the ratio of silica to alumina should be between 2.5 to 4. Thus the correct option would be (3)

7. **Option (3) is correct.**

CsCl has a BCC structure

$$\text{So, body diagonal, } \sqrt{3}a = 2(r_{\text{Cs}^+} + r_{\text{Cl}^-})$$

$$r_{\text{Cs}^+} + r_{\text{Cl}^-} = \frac{\sqrt{3}a}{2}$$

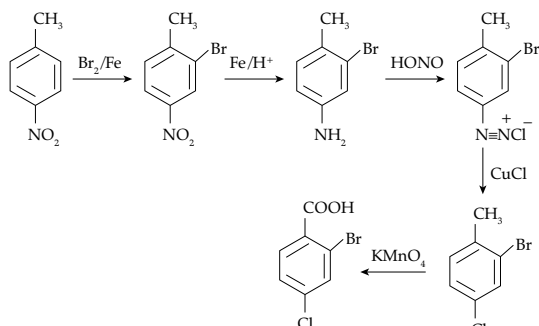
8. **Option (4) is correct.**

According to Bohr's model of hydrogen atom the angular momentum of an electron in a given stationary state is quantized and is equal to $\frac{nh}{2\pi}$.

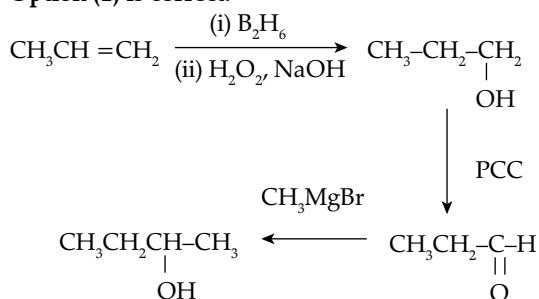
Also the concept of electron in Bohr's orbit violates the Heisenberg uncertainty principle. This is because according to Bohr's theory electrons

revolve around the nucleus in fixed circular paths called orbits, having fixed energies whereas Heisenberg uncertainty principle states that the position and momentum of an electron can never be measured simultaneously, thus both the statements are correct.

9. **Option (2) is correct.**



10. **Option (1) is correct.**



11. **Option (1) is correct.**

Photochemical smog is created by automobile pollution of big cities. Cold place will have minimum photochemical smog. Thus, Srinagar, Jammu and Kashmir in January will have the minimum possibility of Photochemical smog.

12. **Option (3) is correct.**

NF_3 molecule has a pyramidal structure. Electronic configuration of N_2 is $\sigma 1s^2 \sigma 1s^2 \sigma 2s^2 \sigma 2s^2 \pi 2px^2 \pi 2py^2 \sigma 2pz^2$. O_2 is $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2pz^2 \pi 2px^2 \pi 2py^2 \pi 2px^1 \pi 2py^1$

$$\text{Bond order} = \frac{N_b - N_a}{2}$$

$$\text{Bond order of } \text{N}_2 = \frac{10 - 4}{2} = 3$$

$$\text{Bond order of } \text{O}_2 = \frac{10 - 6}{2} = 2$$

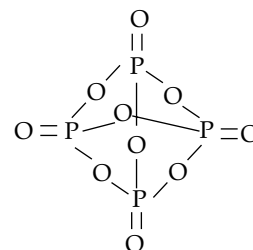
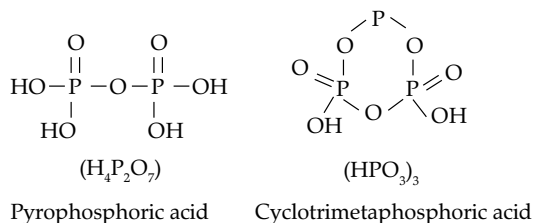
$$\text{Also B.O.} \propto \frac{1}{\text{Bond length}}$$

\therefore Bond length of N_2 is shorter than O_2 . Isoelectronic molecule are those molecule which have same no. of electrons and thus have same bond order. Dipole moment of H_2S is smaller than H_2O . This is because O is more electronegative than S.

Therefore, statements (B) and (C) are correct.

13. **Option (1) is correct.**

The structure of P-O-P bonds in $\text{H}_4\text{P}_2\text{O}_7$, $(\text{HPO}_3)_3$ and P_4O_{10} are shown below:

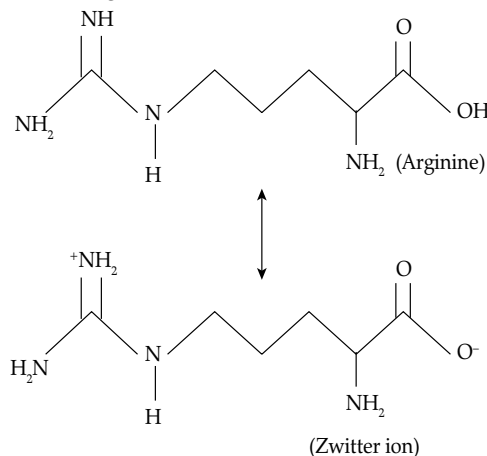


P_4O_{10} : Dimer of phosphorus pentoxide

Thus number of P-O-P bonds in $\text{H}_4\text{P}_2\text{O}_7$, $(\text{HPO}_3)_3$ and P_4O_{10} are respectively 1, 3 and 6.

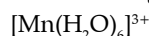
14. **Option (1) is correct.**

Arginine exist in zwitter ion form and thus will be should only in polar solvent and not in benzene. It has 3 pKa values i.e. are 2.17, 9.04 and 12.48. It is a crystalline solid and thus have high melting point due to high molecular mass.



15. **Option (3) is correct.**

The CFSE of given complexes are as follows:



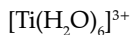
The configuration of Mn^{3+} is $t_{2g}^3 e_g^1$
 $\therefore \text{CFSE} = [3 \times -0.4 + 1 \times 0.6] \Delta_0 = -0.6 \Delta_0$



The configuration of Fe^{3+} is $t_{2g}^3 e_g^2$
 $\text{CFSE} = [3 \times -0.4 + 2 \times 0.6] \Delta_0 = 0$



The configuration of Cr^{3+} is t_{2g}^3
 $\text{CFSE} = [3 \times -0.4 + 0] \Delta_0 = -1.2 \Delta_0$



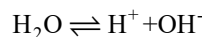
The configuration of Ti^{3+} is t_{2g}^1

$$\text{CFSE} = [1 \times -0.4 + 0] \Delta_0 = -0.4\Delta_0$$

16. **Option (1) is correct.**

The correct statement of paper chromatography is that water present in the pores of the paper forms the stationary phase.

17. **Option (1) is correct.**



$$10^{-8} + x \quad x$$

$$K_w = [\text{H}^+][\text{OH}^-]$$

$$10^{-14} = (x + 10^{-8})(x)$$

$$x^2 + 10^{-8}x - 10^{-14} = 0$$

$$x = \frac{-10^{-8} \pm \sqrt{10^{-16} + 4 \times 10^{-14}}}{2} = 0.95 \times 10^{-7}$$

$$\approx 9.5 \times 10^{-8}$$

$$[\text{H}^+] = 10^{-8} + x = 10.5 \times 10^{-8} \approx 1.05 \times 10^{-7}$$

$$\text{Also } \text{pH} = -\log[1.05 \times 10^{-7}]$$

$$\text{pH} = 6.98$$

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

(C) K_w increases with increase in temperature as the temperature increases the dissociation of water increases.

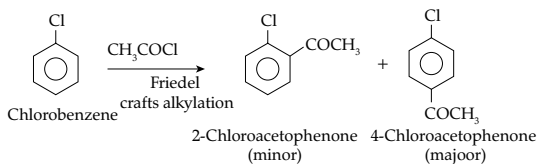
(D) As half neutralization, half of the acid has completely reacted with base and is present in the form of salt. So it forms acidic buffer solution

$$\text{pH} = \text{pKa} + \log \frac{[\text{salt}]}{[\text{acid}]}$$

$$\text{pH} = \text{pKa} + \log 1$$

$$\text{pH} = \text{pKa}$$

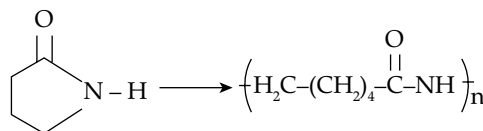
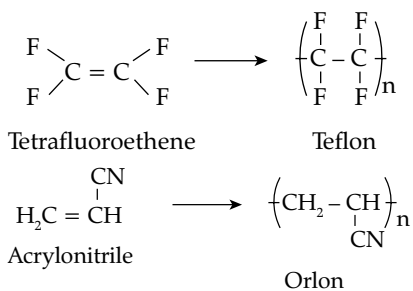
18. **Option (4) is correct.**



19. **Option (3) is correct.**

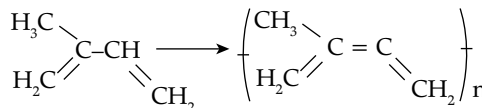
The rate of electrophilic substitution increased by electron donating groups while it gets decreased by electron withdrawing groups. Thus the correct decreasing order of reactivity towards electrophilic substitution reaction is $e > d > a > b > c$.

20. **Option (2) is correct.**



Caprolactam

Nylon-6



Isoprene

Natural rubber

Section B

21. **Correct answer is [1].**

The homoleptic and octahedral complex of Co^{2+} and H_2O is $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$

The electronic configuration of Co^{2+} is $t_{2g}^5 e_g^2$. Thus it has 1 unpaired electron in t_{2g} set of orbital.

22. **Correct answer is [1070].**

Given

Enthalpy change of the reaction $\Delta H = 30.04 \text{ kJ}$

Entropy change of the reaction $\Delta S = 28.4 \text{ J/K/mol}$

We know,

$$\Delta S = \frac{\Delta H}{\text{Temperature}}$$

$$28.4 = \frac{30.4 \times 10^3}{T_{\text{M.P.}}}$$

$$T_{\text{M.P.}} = 1070.422 \text{ K}$$

23. **Correct answer is [5].**

Isoelectronic species are those species which have same number of electrons. The number of electrons given species are as follows:

No. of e⁻s in $\text{O}^{2-} = 10$

No. of e⁻s in $\text{F}^- = 10$

No. of e⁻s in $\text{Mg}^{2+} = 10$

No. of e⁻s in $\text{Na}^+ = 10$

No. of e⁻s in $\text{Al}^{3+} = 10$

No. of e⁻s in $\text{Al} = 13$

No. of e⁻s in $\text{O}^+ = 7$

No. of e⁻s in $\text{Mg} = 12$

No. of e⁻s in $\text{F} = 9$

Thus total number of isoelectronic species in the given set are 5

24. **Correct answer is [130].**

Given,

E_a for an uncatalysed forward reaction = 300 kJ/mole since the rate of catalyzed reaction at 27°C is same as uncatalysed reaction at 327°C

$$\left(\frac{E_a}{T}\right)_{\text{uncatalysed}} = \left(\frac{E_a}{T}\right)_{\text{Catalysed}}$$

$$\frac{300}{600} = \frac{(E)_{\text{forward}}}{300}$$

$$E_a = 150$$

$$\Delta H = E_{af} - E_{ab}$$

$$20 = 150 - E_{ab}$$

$$E_{ab} = 130 \text{ kJ/mol}$$

The activation energy of catalyzed backward reaction is 130 kJ/mol

25. Correct answer is [23].

We know that relative lowering of vapour pressure is given by

$$\frac{P^0 - P_s}{P_s} = \frac{n}{N}$$

$$\text{Density of solution} = \frac{M}{V}; M = 1.2 \times 100 = 120 \text{ g}$$

Given mass of glucose

$$= 30\% \text{ of mass of aqueous solution of glucose}$$

$$= \frac{30}{100} \times 120 = 36 \text{ g}$$

$$\text{No. of moles of glucose} = \frac{36}{180} = 0.2$$

$$\text{Given mass of } H_2O = 120 - 36 \text{ g} = 84 \text{ g}$$

$$\text{No. of moles of } H_2O = \frac{84}{18} = 4.67$$

$$\frac{24 - P_s}{P_s} = \frac{0.2}{4.67}$$

$$24 - P_s = 0.0428 P_s$$

$$P_s = \frac{24}{1.0428} = 23.015 \text{ mm of Hg}$$

26. Correct answer is [6].

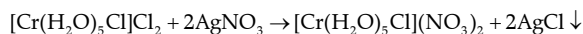
The structure of chromyl chloride is CrO_2Cl_2

Let the oxidation state of Cr be x

$$\therefore x + 2(-2) + 2(-1) = 0$$

$$x = +6$$

27. Correct answer is [4].



$$0.01M \times 20 \qquad 0.1M \times v \qquad 0.2 \text{ mili mole}$$

0.2 milimole of $[Cr(H_2O)_5Cl]Cl_2$ requires 0.4 milimole of $AgNO_3$

$$\therefore 0.1 \times v = 0.4$$

$$v = \frac{0.4}{0.1} = 4 \text{ ml}$$

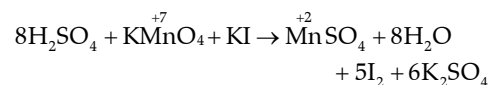
28. Correct answer is [50].

Coagulation value is the minimum concentration of electrolyte required to cause coagulation of one litre of colloidal solution. It is expressed as

$$\text{Coagulation value} = \frac{\text{milimole of electrolyte}}{\text{Volume in sol in L}}$$

$$= \frac{20 \times 0.5}{200} \times 1000 = 50$$

29. Correct answer is [5].



\therefore The change in oxidation state of Mn from $KMnO_4$ to $MnSO_4$ is +5

30. Correct answer is [3].

(A) The conductivity always decreases with decrease in concentration for both strong and weak electrolyte.

(B) The number of ions per unit volume that carry current in a solution decreases on dilution.

(C) Molar conductivity increases with decrease in concentration.

(D) The variation of molar conductivity is different for strong and weak electrolyte.

(E) For weak electrolyte, the change in molar conductivity with dilution is due to increase in degree of dissociation.

Thus the correct statements are (A), (C) and (D).

