

**ASSOCIATION OF CHEMISTRY TEACHERS**  
**NATIONAL STANDARD EXAMINATION IN CHEMISTRY**  
**(NSEC - 2025)**

Time: 120 minute

Max. Marks: 216

*Attempt All Sixty Questions*

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

Solution

1. Chromium in +1 oxidation state has stable half-filled 3d subshell. Therefore, second IE will be very high.  
Ans: c
2. SF<sub>4</sub> has See- Saw structure due to an unshared pair of electrons on S and has net dipole moment.  
Ans: d
3. Dropped
4. Ans: a
5. Pale lilac colour is characteristic of f-block elements not of p block. Also, f block elements do not have significant crystal fields effects, so the trihalides may have same colour. Also, AsF<sub>3</sub> would be a gas. Therefore, central atom is Nd. Nd<sup>+3</sup> is a hard weak acid owing to which its fluoride will be insoluble, but its other halides are expected to be soluble. Dark greenish black colour in D is due to the charge transfer from I. Therefore, halides are F<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup> respectively.  
Ans: d
6. SrO + H<sub>2</sub>O -> 2Sr<sup>+2</sup> + 2OH<sup>-</sup>  
MoO<sub>3</sub> + H<sub>2</sub>O → MO<sub>4</sub><sup>-2</sup> + 2H<sup>+</sup>  
ZrO<sub>2</sub> is insoluble  
Ans: c
7. geometrical (cis-trans) and positional (nitro-nitrito)  
Ans: d
8. Ni in this complex is in 2+ oxidation state. With d8 electronic configuration and in octahedral geometry, it should have 2 unpaired electron. Using  $[n(n+2)]^{1/2}$  formula, it should be 2.83 BM.  
Ans: b
9. Among the give options, CN is the most strong field ligand than NH<sub>3</sub> and then Cl, so (a) is the correct option.  
Ans: a
10. Bond order is = (no. of electrons in bonding molecular orbitals minus no. of electrons in anti-bonding molecular orbitals)/2  
O<sub>2</sub><sup>+</sup> has 2.5; O<sub>2</sub><sup>-</sup> has 1.5; CO has 3; O<sub>2</sub><sup>2-</sup> has 1  
Ans: d
11. Ans: a
12. Label says that 1250 mg of Ca CO<sub>3</sub> per tablet which is dissolved in water to make 1.0 L solution, thus the solution is  $1250/1000 = 1.25 \text{ g}/100 = 0.0125 \text{ M}$   
When 10 mL of this solution is titrated with 0.0198 M EDTA-MgEDTA, by calculation it will require 6.31 mL of the solution (x). Thus the correct answer option is (c).  
Ans: c

13. The mixture of 0.5M each  $\text{NH}_3$  and  $\text{NH}_4\text{Cl}$  forms a buffer and as the property of buffer that the pH doesn't change with addition of small quantity of acid or base to the same. The pH of the buffer is 9.25 by calculation which remains constant in this case. Thus the correct answer option is (c).

Ans: c

14. Greater negative charge on metal enhance back donation of electrons to carbonyl carbon and henceforth bond order (strength) decreases.

Ans: d

15. Ans: c

16.  $\text{CO}_3^{2-}$ ,  $\text{SO}_3$ , and  $\text{BF}_3$  all have  $\text{sp}^2$  hybridization and trigonal planar shape but  $\text{CH}_4$  has  $\text{sp}^3$  and tetrahedral.

Ans: c

17. The molecule, Hex-3-yne is a symmetrical one and on treatment with Na in liquid ammonia, it produces a *trans* alkene.

Ans: b

18. The acetamido group ( $-\text{NHCOCH}_3$ ), being less basic than  $-\text{NH}_2$ , shows stronger +M (mesomeric) effect and thus activates the ring more than the free amino group.

Ans: c

19. Ans: c

20. Ans: b

21. Ans: b

## 22. Isoelectric point (pI):

The pI of an amino acid is the **pH at which the amino acid carries no net charge**. For standard amino acids with non-ionizable side chains,  $\text{pI} \approx$  average of pKa of  $\alpha$ -carboxyl and  $\alpha$ -amino groups. For amino acids with ionizable side chains, the pI depends on the side chain's pKa.

### Given amino acids:

1. **Alanine (Ala)** – Nonpolar, neutral side chain.

- pKa ( $\alpha$ -COOH)  $\approx$  2.34
- pKa ( $\alpha$ - $\text{NH}_3^+$ )  $\approx$  9.69
- **pI = (2.34 + 9.69)/2  $\approx$  6.02**

2. **Arginine (Arg)** – Basic side chain (guanidino group).

- pKa ( $\alpha$ -COOH)  $\approx$  2.17
- pKa ( $\alpha$ - $\text{NH}_3^+$ )  $\approx$  9.04
- pKa (side chain guanidino)  $\approx$  12.48
- **pI = (pKa of  $\alpha$ - $\text{NH}_3^+$  + pKa of side chain)/2  $\approx$  (9.04 + 12.48)/2  $\approx$  10.76**

3. **Glutamic acid (Glu)** – Acidic side chain ( $\gamma$ -COOH).

- pKa ( $\alpha$ -COOH)  $\approx$  2.19
- pKa ( $\alpha$ - $\text{NH}_3^+$ )  $\approx$  9.67
- pKa (side chain  $\gamma$ -COOH)  $\approx$  4.25
- **pI = (pKa of  $\alpha$ -COOH + pKa of side chain)/2  $\approx$  (2.19 + 4.25)/2  $\approx$  3.22**

### Now ordering the pI values:

- Arg  $\approx$  10.76
- Ala  $\approx$  6.02
- Glu  $\approx$  3.22

**Correct order: Arg > Ala > Glu**

Ans: b

23. Only (b) and (d) contain aldehydic groups and (d) can form stable 6 membered ring.  
Ans: d
24. Ans: b
25. Ans: d
26. Ans: c
27. During esterification, chiral center is not disturbed  
Ans: a
28. Reaction proceeds via more stable secondary carbocation.  
Ans: c
29. Ans: d
30. Ans: d
31. Here, the ester hydrolyses via the alkyl oxygen bond cleavage and leading to the formation of an alkene, that can decolourize Br<sub>2</sub> water  
Ans: c
32. Elimination reaction; As the base is a bulkier one, the reaction will take place from the less congested side.  
Ans: c
33. (i) Is false, because 2.50 g of gases with different molar mass cannot have same number of molecules.  
(ii) Is false, because velocity is inversely proportional to molar mass (given all other things are constant / identical)  
(iii) Is true.  $P = nRT/V \rightarrow RT/V$  are constant  $\rightarrow P \propto n \rightarrow$  'n' is number of moles, highest if gas has smallest molar mass for same temperature and pressure  
(iv) Is true.  
Volume (X) =  $n(X) RT/P = ((2.5/40)*0.082*273K)/1 \text{ atm} = 1.399 \text{ L}$   
Volume (Y) =  $n(Y) RT/P = ((2.5/80)*0.082*273K)/1 \text{ atm} = 0.699 \text{ L}$   
Volume (Z) =  $n(Z) RT/P = ((2.5/20)*0.082*273K)/1 \text{ atm} = 2.798 \text{ L}$   
Ans: d
34. Amount of HCl consumed by  $M(OH)_2 = (0.040 \times 0.4) = 0.016 \text{ mol}$  or 16 mmoles  
Number of moles of  $M(OH)_2 = 8 \text{ mmol}$  (since 1  $M(OH)_2$  equivalent to 2 HCl)  
30 g of sample contains 8 mmol of  $M(OH)_2$  or 0.52 g of  $M(OH)_2$   
Percent purity =  $0.52/30 = 1.73 \%$   
  
Ans: a
35.  $\frac{k_1}{k_2} = \exp\left(\frac{-E_{a1} - (-E_{a2})}{RT}\right) = \exp\left(\frac{-E_{a1} + 3E_{a1}}{RT}\right)$   
Ans: b
36. 10 days, 2 astronauts, 500 L per person per day = 10000 L of O<sub>2</sub>  
Number of moles of O<sub>2</sub> =  $10000/(0.082 * 300) = 406.5 \text{ mol}$   
406.5 mol of O<sub>2</sub> = 406.5 mol of KClO<sub>3</sub> =  $(406.5 * 122.55) \text{ g of KClO}_3 = 49.82 \text{ kg}$   
Ans: a

37. Entropy will increase due to spontaneous mixing in the isolated system. Volume will increase due to the greater volume of steam (some water will remain as steam)

Ans: a

38. Ans: b

39. The half-life is constant  $\rightarrow$  Hence, first order reaction  $\rightarrow$  Unit of rate constant for first order reaction is  $s^{-1}$ . Unit of rate is always (concentration / time)

Ans: d

40. For a first order reaction, the rate equation is:

$$k = \frac{2.303}{10} \log \frac{0.35}{0.035} = 0.2303 \times \log 10 = 0.2303 \text{ s}^{-1}$$

$$0.2303 = \frac{2.303}{t} \log \frac{0.35}{0.00035}$$

$$t = \frac{2.303}{0.2303} \log \frac{0.35}{0.00035} = 10 \times 3 = 30$$

Ans: b

41.  $pK_a = pH - \log[\text{salt}]/[\text{acid}] = 3 - \log(0.001/0.2) = 3 + 2.3010 = 5.3010$

$pH = pK_a + \log[\text{salt}]/[\text{acid}] = 5.6 + \log(0.1/0.05) = 5.3010 + \log 2 = 5.3010 + 0.3010 = 5.6$

Ans: c

42. Concentration of  $M^2$  required for precipitation

$$MSO_3 \text{ salt} = \frac{7 \times 10^{-7}}{0.01} = 7 \times 10^{-5} \text{ M}$$

$$MF_2 \text{ salt} = \frac{5 \times 10^{-9}}{0.01^2} = 5 \times 10^{-5} \text{ M}$$

$$M_3(PO_4)_2 \text{ salt} = \left( \frac{1 \times 10^{-25}}{0.01^2} \right)^{\frac{1}{3}} = 1 \times 10^{-7} \text{ M}$$

The order of concentration required is  $M_3(PO_4)_3 < MF_2 < MSO_3$

Thus, the order of precipitation will be  $M_3(PO_4)_3 < MF_2 < MSO_3$

Ans: a

43. Van't Hoff factor,  $i = 0.558/(1.86 \times 0.1) = 3$

Hence, dissociation should lead to 3 ionic species i.e.  $[Cr(NH_3)_5Cl]Cl_2$

Ans: b

44. MW of salicylic acid ( $C_7H_6O_3$ ) = 138 g/mol

MW of acetic anhydride ( $C_4H_6O_3$ ) = 102 g/mol

MW of aspirin ( $C_9H_8O_4$ ) = 180 g/mol

155 g of salicylic acid = 1.12 mol

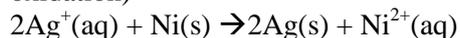
105 g of acetic anhydride = 1.029 mol

Amount of aspirin produced =  $0.8 \times 1.029 = 0.8235$  mol

Weight of aspirin produced =  $0.8235 \times 180 = 148.2$  g

Ans: a

45.  $\text{Ag}^+(\text{aq})/\text{Ag}(\text{s})$  acts as cathode (i.e. undergoes reduction) and  $\text{Ni}^{2+}(\text{aq})/\text{Ni}(\text{s})$  acts as anode (i.e. undergoes oxidation)



$$E^\circ_{\text{cell}} = 0.799 + 0.236 = 1.035 \text{ V}$$

$$E_{\text{cell}} = 1.035 - \frac{0.0592}{2} \log \frac{[\text{Ni}^{2+}]}{[\text{Ag}^+]^2} = 1.12$$

$$0.17/0.0592 = 2.8716 = \log[\text{Ni}^{2+}] - 2\log(0.005) = \log[\text{Ni}^{2+}] + 4.6020$$

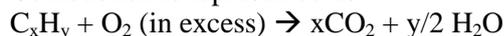
$$\log[\text{Ni}^{2+}] = -1.7304$$

$$[\text{Ni}^{2+}] = 0.018 \text{ M}$$

Since Ni undergoes oxidation, concentration of Ni(II) will increase with time.

Ans: a

46. Combustion is represented as:



$$11.93 \text{ g of CO}_2(\text{g}) = 0.27 \text{ mol of C} = 3.25 \text{ g of C}$$

$$2.19 \text{ g of H}_2\text{O}(\text{g}) = 0.121 \text{ mol of H}_2\text{O} = 0.243 \text{ mol of H} = 0.243 \text{ g of H}$$

$$\text{Mass of hydrocarbon} = 3.493 \text{ g}$$

Ans: a

47. Wavelength of photon  $\propto 1/\text{Energy}$

(a)  $n = 1 \rightarrow n = 3$

$$\text{Energy required} = R_H (1 - 1/9) = 0.89 R_H$$

(b)  $n = 2 \rightarrow n = 6$

$$\text{Energy required} = R_H (1/4 - 1/36) = 0.22 R_H$$

(c)  $n = 3 \rightarrow n = 1$

Is not an absorption

(d)  $n = 1 \rightarrow n = 6$

$$\text{Energy required} = R_H (1 - 1/36) = 0.972 R_H$$

Lowest energy for (b), hence highest wavelength absorbed

Ans: b

48. (a) is incorrect. Reaction B is endothermic and the equilibrium constant increases with an increase in temperature.

(b) is incorrect. The entropy change of reaction A is  $(-25000/500) = -50 \text{ J/ K.mol}$

(c) is correct as seen from the graph (positive values of  $RT\ln K$  indicate negative  $\Delta G$  i.e. spontaneous change)

(d) is incorrect – the slope of the plot ( $K$  as a function of temperature) and hence, the enthalpy remains the same

Ans: c

## A – 2

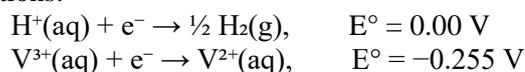
ANY NUMBER OF OPTIONS (4, 3, 2 or 1) MAY BE CORRECT  
 MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED AND NO INCORRECT.

49. Cyclopentadiene is the most acidic of the three hydrocarbons given above and n-butane is the least.  
 Ans: a

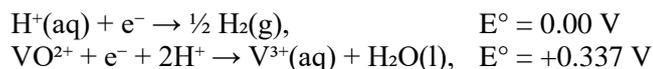
50. It gave positive chromyl chloride test indicates chloride. a violet-coloured organic layer indicates iodide. Brown ring test was positive but brown coloured gas was not intensified on heating the mixture with copper turnings and concentrated sulphuric acid indicates that it could be bromide or nitrate but brown coloured gas was not intensified on heating the mixture with copper turnings and concentrated sulphuric acid certainly indicate bromide present and nitrate absent. Thus the correct answer option is (a)

Ans: a

51. In this case you have to consider two potential reactions: (i) possible oxidation by  $H^+$  and (ii) possible oxidation by  $O_2$ . The first case has been covered in the text, but we can look at the two half-reactions, assuming standard conditions:



Thus, the overall reaction,  $V^{2+}(aq) + H^+(aq) \rightarrow V^{3+}(aq) + \frac{1}{2} H_2(g)$ , would have a positive potential difference ( $E = +0.255 \text{ V}$ ) and the reaction is spontaneous. (Recall that reactions with a positive potential difference have negative  $\Delta rG$  and are thus spontaneous.) Further oxidation of  $V^{3+}(aq)$  by  $H^+(aq)$  is not feasible because the potential difference would be negative. For example, consider the half-reaction for oxidation of  $V^{3+}(aq)$  to  $VO^{2+}(aq)$  by  $H^+(aq)$ :



Combining these two reactions would lead to a negative potential difference ( $E = -0.337 \text{ V}$ ) and a nonspontaneous reaction.

The reduction potential for  $O_2(g)$  in acidic medium is  $+1.23 \text{ V}$  (for half-reaction  $\frac{1}{2} O_2(g) + 2e^- + 2H^+ \rightarrow H_2O(l)$ ), meaning that  $O_2$  is a better oxidizing agent than  $H^+$ . Consequently,  $O_2(g)$  will be able to oxidize  $V^{2+}(aq)$  to  $V^{3+}(aq)$  as well, but we have to check if oxidation of  $V^{3+}(aq)$  to  $VO^{2+}(aq)$  is now possible:  $E = +1.23 \text{ V} - (+0.337 \text{ V}) = +0.893 \text{ V}$ . The potential difference is positive, and  $VO^{2+}(aq)$  should be more stable than  $V^{3+}(aq)$  and  $V^{2+}(aq)$  under these conditions. Similar analysis shows that  $VO^{2+}(aq)$  could be further oxidized to  $VO_2^+(aq)$  with potential difference of  $+0.23 \text{ V}$ . Overall, this indicates that  $V^{2+}(aq)$  should be oxidized by  $O_2(g)$  in the acidic solution all the way to the thermodynamically favoured species  $VO_2^+(aq)$ . Note that this does not necessarily mean that the process will occur—the kinetics might be slow, and particular importance has to be considered when dealing with  $O_2(g)$  oxidation—are over potentials. Consequently,  $V^{3+}(aq)$  and/or  $VO^{2+}$  might be reasonably long-lived species in acidic medium when exposed to oxygen from air.

Ans: a, b, d

52. The first three options are correct and also (d) as the thermal decomposition is under controlled condition where it is expected that if  $NH_3$  is present outside the coordination entity it will get vapourised under controlled condition which will help in determination of the formula.

Ans: a, b, c, d

53. Ans: b, c, d

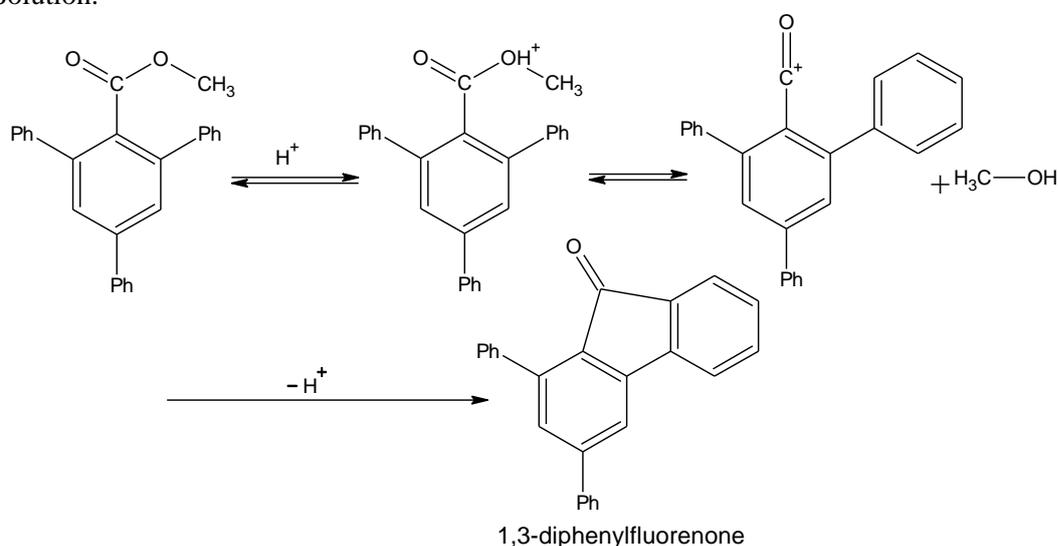
54. Ans: a, b, c, d

- Optical rotation of a disaccharide is not the arithmetic sum of the rotations of its constituent monosaccharides.
- (+)/(-) indicate the direction of optical rotation (experimental property).
- D/L indicate relative configuration with respect to glyceraldehyde (structural property).
- There is no necessary correlation between D/L and (+)/(-).
- In glucose, the predominant cyclic form is a six-membered pyranose ring.
- This hemiacetal is formed by bond formation between:
- C1 (aldehyde carbon) and C5 (-OH group)
- C1-C6 cyclization would form a seven-membered ring, which is not predominant.
- DNA contains 2-deoxy-D-ribose
- RNA contains D-ribose

Hence, not all nucleic acids contain 2-deoxy-D-ribose.

Ans: a, b, c, d

55. Solution:



Ans: b, d

56. Ans: a, b, c, d

57. NaCl is an electrolyte, hence total concentration of solute = 0.070 M (assuming density of solution is 1 gm/cm<sup>3</sup>)

For vapour pressure to equilibrate, water will be transferred from more “concentrated” solution i.e. beaker B to the beaker with the lower concentration i.e. beaker A till the activity of both solutions is equal.

Let ‘x’ mL of water be transferred from B to A

$$(30 - x) \cdot 0.07 = (30 + x) \cdot 0.05$$

$$X = 5 \text{ mL}$$

Ans: b, c

58. (a) is correct

Pressure  $\propto$  Number of moles (number of particles)

$$P(\text{box i}) = P(\text{box iii}) > p(\text{box ii})$$

(b) Is incorrect

Partial pressure of helium is highest in box i

$$P(\text{box ii}) = P(\text{box iii}) \cdot (4/7)$$

$$P_{\text{He}}(\text{box ii}) = 0.75 \cdot P(\text{box ii}) = 0.75 \cdot P(\text{box iii}) \cdot (4/7) = P(\text{box iii}) \cdot (3/7)$$

$$P_{\text{He}}(\text{box iii}) = P(\text{box iii}) \cdot (2/7)$$

$$P_{\text{He}}(\text{box ii}) > P_{\text{He}}(\text{box iii})$$

(c) is correct

Density of box (mass per unit volume) is in the order  $\text{iii} > \text{i} > \text{ii}$ .

(d) is incorrect

Pressure of box (i) and (iii) are equal since equal moles of gas exert equal pressure (irrespective of composition)

Ans: a, c

59. Isotonic properties are due to equal total molar concentration of all species in the solutions

(a) 100 mL 0.5 M glucose solution + 110 mL 0.2 M  $\text{CuSO}_4$  solution

$$(0.5 \cdot 100)/210 + (0.2 \cdot 110)/210 = (50 + 22)/210 = 0.343 \text{ M}$$

(b) 200 mL 0.5 M acetamide solution + 300 mL 0.1 M NaCl solution

$$(0.5 \cdot 200)/500 + (0.1 \cdot 2 \cdot 300)/500 = (100 + 60)/500 = 0.32 \text{ M}$$

(c) 400 mL 0.1 M  $\text{BaCl}_2$  solution + 100 mL 0.2 M KCl solution

$$(0.1 \cdot 400 \cdot 3)/500 + (0.2 \cdot 2 \cdot 100)/500 = (120 + 40)/500 = 0.32 \text{ M}$$

(d) 200 mL 0.13 M  $\text{CaCl}_2$  solution + 200 mL 0.125 M HCl solution

$$(0.13 \cdot 3 \cdot 200)/400 + (200 \cdot 0.125 \cdot 2)/400 = (78 + 50)/400 = 0.32 \text{ M}$$

Ans: b, c, d

60. (a) Is correct

$$\text{Number of moles in the system} = n(\text{Ne}) + n(\text{Xe}) + n(\text{Ar})$$

$$= 2/RT + 1/RT + 0.5/RT = 3.5/RT$$

$$\text{Total pressure} = nRT/(\text{Total volume}) = 3.5/2 = 1.75 \text{ atm}$$

(b) Is incorrect

Partial pressure of Ne will be equal in all cylinders due to uniform mixing and hence uniform composition in all cylinders

(c) Is correct

The order of partial pressures will be same as the order of the mole fractions i.e. in turn dependent on number of moles of a given gas.

$$\text{Since, } n(\text{Ne}) > n(\text{Xe}) > n(\text{Ar}) \rightarrow p(\text{Ne}) > p(\text{Xe}) > p(\text{Ar})$$

(d) Is correct

Since the pressure reduces from 2 atm to 1.75 atm, it indicates a lower number of moles occupying cylinder 2

Ans: a, c, d