

Victoria Junior College
2016 JC2 H2 Chemistry Prelim Paper 1
Suggested Answers

No.	Ans	No.	Ans	No.	Ans	No.	Ans
1	D	11	C	21	A	31	B
2	A	12	B	22	D	32	B
3	B	13	C	23	A	33	A
4	A	14	A	24	B	34	D
5	D	15	D	25	C	35	D
6	C	16	B	26	B	36	A
7	D	17	D	27	A	37	A
8	C	18	B	28	B	38	D
9	A	19	C	29	D	39	B
10	C	20	C	30	C	40	D

1 D

In H_3^+ ,
 $p = 3$, $n = 0$, $e = 3 - 1 = 2$ (one less e than p)

2 D

No. of moles of helium remains the same at the two temperatures. Using $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$,
 $\frac{1 \times 10^5 \times V_1}{20 + 273} = \frac{P_2 \times (V_1 + 3V_1)}{100 + 273}$
 $P_2 = 3.18 \times 10^4 \text{ Pa}$

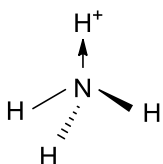
3 B

Mass of CaCO_3 in one chicken's egg shell
 $= 50 \times \frac{5}{100} = 2.5 \text{ g}$
 No. of moles of CaCO_3 in one chicken's egg shell
 $= 2.5 \div 100.1 = 0.025 \text{ mol}$
 No. of moles of ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$ used
 $= 2.0 \times 50 \times 10^{-3} = 0.10 \text{ mol}$
 $2\text{CH}_3\text{CO}_2\text{H} + \text{CaCO}_3 \rightarrow \text{Ca}^{2+}(\text{CH}_3\text{CO}_2^-)_2 + \text{H}_2\text{O} + \text{CO}_2$
 No. of moles of CaCO_3 needed
 $= 0.10 \div 2 = 0.050 \text{ mol}$
 No. of complete chicken's egg shells needed
 $= 0.050 \div 0.025 = 2$

4 A

Equation:
 $\text{Al}_4\text{C}_3 + 4\text{NaOH} + 4\text{H}_2\text{O} \rightarrow 4\text{NaAlO}_2 + 3\text{CH}_4$
 Hydrocarbon is CH_4 .

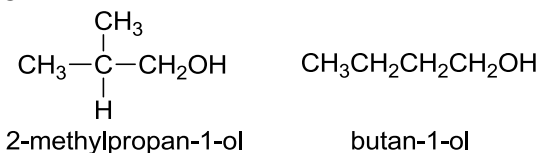
5 D



NH_4^+ is tetrahedral. The bond angles are 109° and the bonds are all of the same length.
 NH_4^+ ions are formed when NH_3 behaves as a base, i.e. a proton acceptor.

On heating, $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$

6 C



Option A: Both 2-methylpropan-1-ol and butan-1-ol can form intermolecular hydrogen bonds due to the presence of $-\text{OH}$ in the molecules.

Option B: Both molecules have strong covalent bonds between their atoms.

Options C and D: 2-methylpropan-1-ol has weaker dispersion forces than butan-1-ol as 2-methylpropan-1-ol is more spherical and has less (not more) surface area for electron interaction than butan-1-ol.

7 D

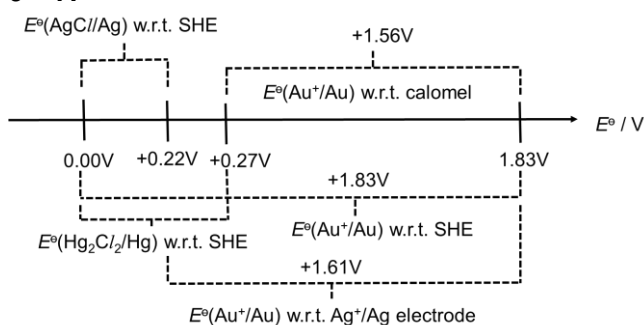
Options A, B and D: K_{eq} is unaffected by increasing the pressure, adding a catalyst or a shift in position of equilibrium. K_{eq} is only affected by a change in temperature. Hence ΔG_{eq} has the same value at constant temperature.

Option C: When $K_{\text{eq}} < 1$, $\lg K_{\text{eq}}$ will be negative and ΔG_{eq} will be positive according to the equation $\Delta G_{\text{eq}} = -2.303 RT \lg K_{\text{eq}}$, i.e. the dissolution of CO_2 in water is non-spontaneous when $K_{\text{eq}} < 1$.

8 C

$(\text{CH}_3\text{CHO})_4(\text{s}) + 10 \text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 8\text{H}_2\text{O}(\text{l})$
 $\Delta H^\ominus_{\text{c}}$ metaldehyde
 $= (8\Delta H^\ominus_{\text{f}} \text{CO}_2 + 8\Delta H^\ominus_{\text{f}} \text{H}_2\text{O}) - \Delta H^\ominus_{\text{f}} \text{metaldehyde}$
 Hence $\Delta H^\ominus_{\text{f}} \text{metaldehyde}$
 $= (8\Delta H^\ominus_{\text{f}} \text{CO}_2 + 8\Delta H^\ominus_{\text{f}} \text{H}_2\text{O}) - \Delta H^\ominus_{\text{c}} \text{metaldehyde}$
 $= (8\Delta H^\ominus_{\text{c}} \text{carbon} + 8\Delta H^\ominus_{\text{c}} \text{hydrogen}) - \Delta H^\ominus_{\text{c}} \text{metaldehyde}$

9 A



Option A: $E^\ominus(\text{Au}^+/\text{Au})$ wrt the SHE $= +1.56 + (+0.27) = +1.83 \text{ V}$ (refer to diagram above)

Option B: $E^\ominus(\text{Au}^+/\text{Au})$ wrt the AgCl/Ag electrode $= +1.56 + (0.27 - 0.22) = +1.61 \text{ V}$ (refer to diagram above)

Option C: The reduction potential of AgCl/Ag half-cell ($+0.22 \text{ V}$) is more positive than that of H^+/H_2 half-cell (0.00 V). Hence Ag has a lower tendency to be oxidised than H_2 .

Option D: The reduction potential of $\text{Hg}_2\text{Cl}_2/\text{Hg}$ half-cell ($+0.27 \text{ V}$) is more positive than that of AgCl/Ag half-cell ($+0.22 \text{ V}$). Hence Hg_2Cl_2 has a higher tendency to be reduced than AgCl .

10 C

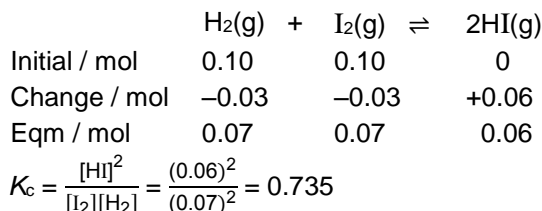
Let volume of $0.100 \text{ mol dm}^{-3} \text{ NaOH}$ added be $V \text{ cm}^3$.

$\text{NaOH} + \text{CH}_3\text{CO}_2\text{H} \rightarrow \text{CH}_3\text{CO}_2^- \text{Na}^+ + \text{H}_2\text{O}$

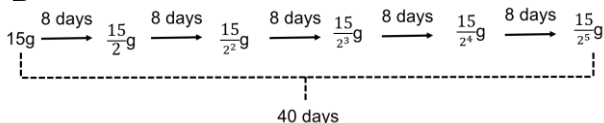
No. of moles of NaOH added (limiting reagent)
 $= 0.100 V \div 1000 = V \times 10^{-4} \text{ mol}$
 $= \text{no. of moles of } \text{CH}_3\text{CO}_2^-$

No. of moles of $\text{CH}_3\text{CO}_2\text{H}$ left
 $= (0.100 \times 20 \div 1000) - (V \times 10^{-4})$
 $= (20 - V) \times 10^{-4} \text{ mol}$
 $K_a = \frac{[\text{H}^+][\text{CH}_3\text{CO}_2^-]}{[\text{CH}_3\text{CO}_2\text{H}]}$
 $1.8 \times 10^{-5} = \frac{(10^{-5.5})(V \times 10^{-4})}{(20 - V) \times 10^{-4}}$
 $V = 17.0 \text{ cm}^3$

11 C



12 B



40 days is equivalent to 5 half-lives; hence the mass of ^{131}I left would be $\frac{15}{2^5} \text{ g}$.

13 C

Option A shows the properties of a Group I element.
 Option B shows the properties of a non-metal with low electrical conductivity.
 Option C shows the properties of a Group II element with relatively high melting point and has high electrical conductivity. Melting point is higher for Group II elements than Group I elements due to stronger metallic bonds.
 Option D shows the properties of a transition metal with very high melting point $> 1000^\circ\text{C}$ and very high density.

14 A

From the acid-base nature of the oxides, it can be deduced that X is in Group III, Y is in Group I or Group II, and Z is a non-metal. Since ionic radius of metal ion decreases across the period due to increasing nuclear charge, ion of X is smaller than ion of Y. Non-metal ion of the same period has a larger ionic radius than a metal ion as it gains electrons to form an additional shell of electrons. Hence, ion of Z has the largest ionic radius.

15 D

Option A: Phosphorus also forms two acidic oxides, P_4O_6 and P_4O_{10} .
 Option B: Ar has the highest 1st ionisation energy.
 Option C: Phosphorus and chlorine can also form compounds with variable oxidation states, e.g. PCl_3 and PCl_5 , Cl^- and ClO^- .
 Option D: Only sulfur exists as S_8 simple molecules.

16 B

In hot $\text{KOH}(\text{aq})$, Cl_2 undergoes disproportionation reaction as shown below.



17 D

Formula of complex

- I $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
 II $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
 III $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
 IV $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

Option A: All complexes, I to IV, have coordination number of 6.

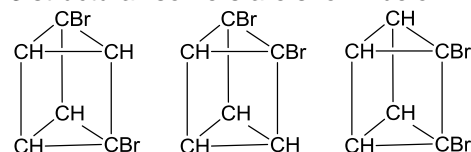
Option B: Charge of the cation depends on how many Cl^- ligand it has. Only cations in complexes III and IV have the same charge of +1. Cation in complex I has a charge of +3 and cation in complex II has a charge of +2.

Option C: Complex I only consists of ammonia ligands since all 3 moles of Cl^- are precipitated by AgNO_3 per mole of the complex.

Option D: Complexes III and IV have the same structural formula but the ligands have different arrangement in space as they have different colours.

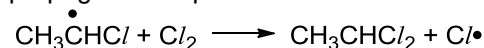
18 B

3 structural isomers are shown below.

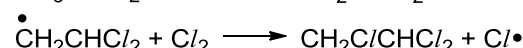
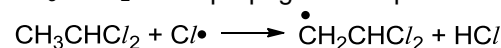


19 C

Option A: CH_3CHCl_2 can be formed from one of the propagation steps:

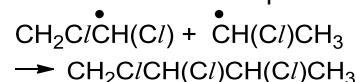


Option B: $\text{CHCl}_2\text{CH}_2\text{Cl}$ can be formed from CH_3CHCl_2 in the propagation step:



Option C: $\text{CH}_3\dot{\text{C}}\text{H}_2$ is not produced from $\text{CH}_3\text{CH}_2\text{Cl}$ as the $\text{C}-\text{Cl}$ bond is not broken. Hence $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ is not likely to be formed.

Option D: $\text{CH}_2\text{ClCH}(\text{Cl})\text{CH}(\text{Cl})\text{CH}_3$ can be formed from a termination step:

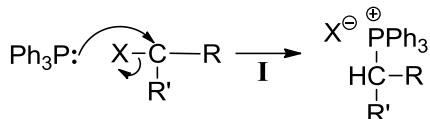


20 C

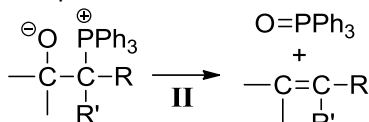
Positive test with Tollens' reagent \Rightarrow U contains $-\text{CHO}$ group. Since U is oxidised by acidified $\text{K}_2\text{Cr}_2\text{O}_7$ to $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$, U is $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CHO}$. U can be reduced by NaBH_4 to form V, $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$, which reacts with CH_3COCl to form an ester W, $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OCOCH}_3$.

21 A

Nucleophilic substitution of $-X$ by $:PPh_3$ in stage I.



Elimination by removal of atom or groups of atoms from adjacent carbon atoms in stage II to form a multiple bond.



[In condensation reaction, two molecules react and become covalently bonded with the concurrent loss of a small molecule, e.g. H_2O , HCl .]

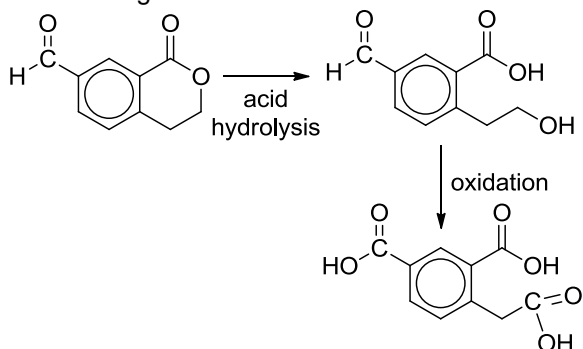
22 D

Option A: The benzaldehyde is reduced by H_2 , Pd. However, there is no visible observation to distinguish between the two compounds.

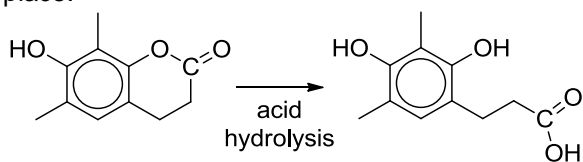
Option B: Phenol cannot react with $Br_2(aq)$ in this question as it has substituents at the 2-, 4- and 6-positions w.r.t. the phenol functional group.

Option C: The benzaldehyde cannot react with Fehling's reagent. It can only react with Tollens' reagent.

Option D: Orange acidified $K_2Cr_2O_7$ turns green for the following molecule.



Orange acidified $K_2Cr_2O_7$ remains orange for the following molecule as there is no oxidation taking place.



23 A

Size of atom: $F < Cl < Br < I$

Strength of bond: $C-F > C-Cl > C-Br > C-I$

The larger the size of the halogen atom, the longer and weaker the $C-X$ bond (where $X = F, Cl, Br, I$) which is more easily broken. Hence $C-I$ bond is most easily broken and the I^- ions formed will react with $Ag^+(aq)$ to form a yellow precipitate of AgI .

24 B

Option A: Warfarin has 2 stereoisomers as it has only one chiral centre. It has no geometric isomers as the $C=C$ bond is found in the ring structure.

Option B: The $-OH$ group reacts with CH_3COCl to form an ester and white fumes of HCl .

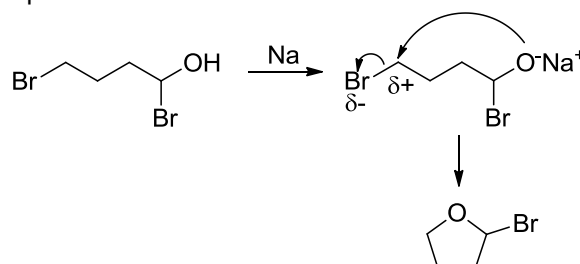
Option C: Warfarin does not react with $KCN(alc)$ in the presence of heat as there is no alkyl halide (i.e. RX) present. The ketone functional group present in Warfarin can react with HCN , $NaCN$ catalyst at room temperature, not $KCN(alc)$.

Option D: 1 mol of warfarin reacts with 2 mol of H_2 gas in the presence of nickel catalyst and heat as both the ketone and the alkene functional groups are reduced.

25 C

Option A: $CH_3CHBrCH_3$ undergoes elimination reaction with $CH_3CH_2O^-Na^+(alc)$, reflux to form $CH_3CH=CH_2$.

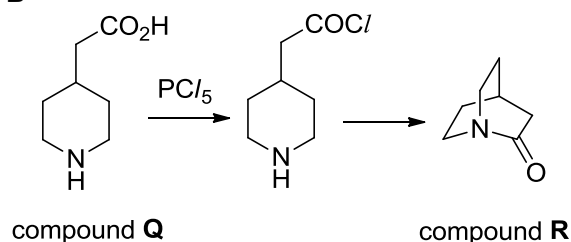
Option B:



Option C: Amine does not react with carboxylic acid to form amide. N.B. Amine reacts with acyl chloride to form amide.

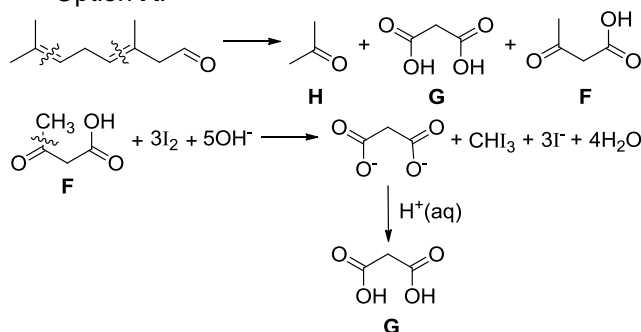
Option D: $-CN$ is reduced by H_2 , Pt to $-CH_2NH_2$.

26 B

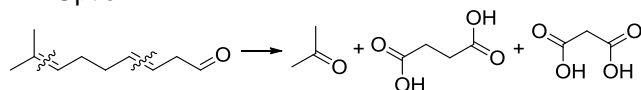


27 A

Option A:

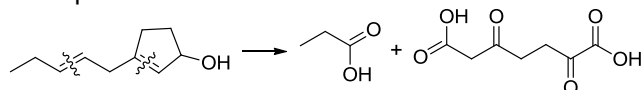


Option B:



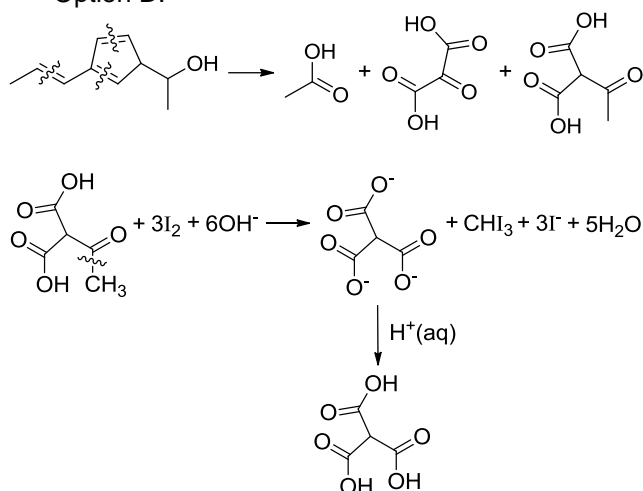
None of the products react with alkaline aqueous iodine to form any of the other product.

Option C:



Only two products are formed.

Option D:



28 B

Both the amide and ester functional groups will undergo acid hydrolysis. Amine will undergo acid-base reaction with HCl(aq) .

29 D

Options A and B: LiAlH_4 in dry ether is unable to reduce alkene.

Option C: KMnO_4 with $\text{H}_2\text{SO}_4(\text{aq})$, heat will cause both $-\text{CH}_2\text{OH}$ and $-\text{CH}_2\text{CH}_2\text{CH}_3$ side chains on the benzene ring to be oxidised to $-\text{CO}_2\text{H}$ as both side chains have a benzylic hydrogen.

Option D: Both aldehyde and alkene functional groups will be reduced by H_2 , Pt. Only the primary alcohol will be oxidised by $\text{K}_2\text{Cr}_2\text{O}_7$ with $\text{H}_2\text{SO}_4(\text{aq})$, heat to form $-\text{CO}_2\text{H}$.

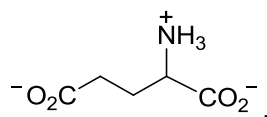
30 C

Point S corresponds to the second equivalence

point for the titration of $\text{HO}_2\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}(\text{NH}_3^+)-\text{CO}_2\text{H}$ with NaOH .

Relative acid strength: $\alpha-\text{CO}_2\text{H} > \text{alkyl}-\text{CO}_2\text{H} > \alpha-\text{NH}_3^+$.

Thus the species present at point S is



31 B (1 and 2 only are correct)

Option 1: Correct

Since $[\text{HBr}]$ is in the denominator of the rate equation, an increase in its concentration will lower the value of rate.

Option 2: Correct

For the hydrogen / iodine reaction, the given rate equation follows the molecularity of the given equation ($\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightarrow 2\text{HI}(\text{g})$) but this is not the case for the hydrogen / bromine reaction. Hence, the slow rate determining step involves 1 molecule of H_2 and 1 molecule of I_2 , which could be a single step reaction for the hydrogen / iodine reaction.

Option 3: Incorrect

There is no evidence from the rate equation that the mechanism of the hydrogen / bromine reaction involves free radicals.

32 B (1 and 2 only are correct)

Option 1: Correct

From $\text{Mg(s)} + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$, the enthalpy change of formation of MgCl_2 is -642 kJ mol^{-1} , i.e. the energy change when 1 mol of MgCl_2 is formed from its constituent elements in their standard states, Mg(s) and $\text{Cl}_2(\text{g})$.

Option 2: Correct

From $\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{g})$,
 $+2334 = \Delta H_{\text{atom}}(\text{Mg}) + 1^{\text{st}} \text{ I.E.} + 2^{\text{nd}} \text{ I.E.}$

$\Delta H_{\text{atom}}(\text{Mg}) = +2334 - 736 - 1450 = +148 \text{ kJ mol}^{-1}$

Option 3: Incorrect

From $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{g})$,
 $-454 = \text{B.E.}(\text{Cl}-\text{Cl}) + 2(1^{\text{st}} \text{ E.A.})$

$1^{\text{st}} \text{ E.A.} = (-454 - 244) \div 2 = -349 \text{ kJ mol}^{-1}$

33 A (1, 2 and 3 are correct)

Option 1: Correct

$\text{NaBO}_2 + 6\text{H}_2\text{O} + 8\text{e}^- \rightleftharpoons \text{NaBH}_4 + 8\text{OH}^- \quad E^\ominus = -1.24 \text{ V}$

$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons 4\text{OH}^- \quad E^\ominus = +0.40 \text{ V}$

$E^\ominus_{\text{cell}} = 0.40 - (-1.24) = +1.64 \text{ V}$

Option 2: Correct

NaBH_4 is oxidised to NaBO_2 at the anode X while O_2 is reduced to OH^- at the cathode Y.

Option 3: Correct

$\text{O}=\text{B}=\text{O}^-$ The BO_2^- anion has 2 bond pairs and 0 lone pair around the central B atom, giving it a linear shape with a bond angle of 180° .

34 D (1 only is correct)

Option 1: Correct

$\text{Ca(OH)}_2(\text{s}) \rightleftharpoons \text{Ca}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$

Let the solubility of Ca(OH)_2 be $y \text{ mol dm}^{-3}$.

$[\text{Ca}^{2+}][\text{OH}^-]^2 = 4.7 \times 10^{-6}$

$(y)(2y)^2 = 4.7 \times 10^{-6}$

$y = 0.0106 \text{ mol dm}^{-3}$

$[\text{OH}^-] = 2y = 0.021 \text{ mol dm}^{-3}$

Option 2: Incorrect

When equal volumes of solutions are mixed together, dilution occurs and their concentrations are halved. Hence, new $[\text{Ca}^{2+}] = 0.01 \text{ mol dm}^{-3}$ and new $[\text{OH}^-] = 0.01 \text{ mol dm}^{-3}$.

Ionic product = $[\text{Ca}^{2+}][\text{OH}^-]^2 = (0.01)(0.01)^2 = 1.0 \times 10^{-6} < 4.7 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$

Since ionic product $< K_{\text{sp}}(\text{Ca(OH)}_2)$, precipitation will not occur.

Option 3: Incorrect

Sn(OH)_2 has the lowest solubility amongst the three metal hydroxides.

metal hydroxide	K_{sp}	Solubility / mol dm^{-3}
Ca(OH)_2	$4.7 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$	0.0106
Sn(OH)_2	$5.4 \times 10^{-27} \text{ mol}^3 \text{ dm}^{-9}$	1.11×10^{-9}

Cr(OH) ₃	$6.7 \times 10^{-31} \text{ mol}^4 \text{ dm}^{-12}$	1.26×10^{-8}
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35 D (1 only is correct)

Option 1: Correct

Down the group, cationic radius increases and charge density of M^{2+} decreases. Polarising power of M^{2+} decreases and the electron cloud of iodate(V) ion is less distorted. Thermal stability of $M(\text{IO}_3)_2$ increases.

Option 2: Incorrect

Since $\text{L.E.} \propto \frac{q^+q^-}{r_+ + r_-}$, magnitude of L.E. decreases down the group with increasing cationic radius, r_+ .

Option 3: Incorrect

Charge density of M^{2+} ion decreases down the group as ionic radius increases while the charge remains the same.

36 A (1, 2 and 3 are correct)

Option 1: Correct

Overall charge of complex is neutral with two Cl^- ligands and one RCO_2^- ligand. Hence the oxidation number of **M** is +3.

Option 2: Correct

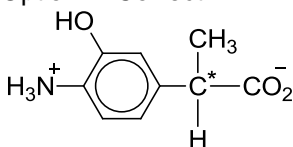
Coordination number is the number of dative bonds around **M** which is equal to 6 in the complex.

Option 3: Correct

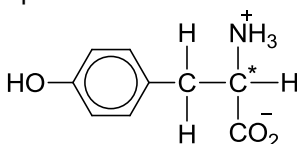
Besides the two Cl^- ligands, the other four dative bonds are from the same tetradentate ligand.

37 A (1, 2 and 3 are correct)

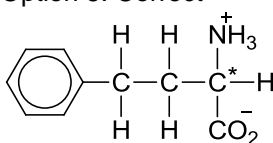
Option 1: Correct



Option 2: Correct



Option 3: Correct



38 D (1 only is correct)

Option 1: Correct

Molecule **I** is the cis isomer and molecule **II** is the trans isomer, hence they are stereoisomers. Both $-\text{NO}_2$ and Br are electron-withdrawing in nature. Since these two groups are on the same side of the $\text{C}=\text{C}$ bond in molecule **I**, the overall dipole moment is larger than that in molecule **II**.

Option 2: Incorrect

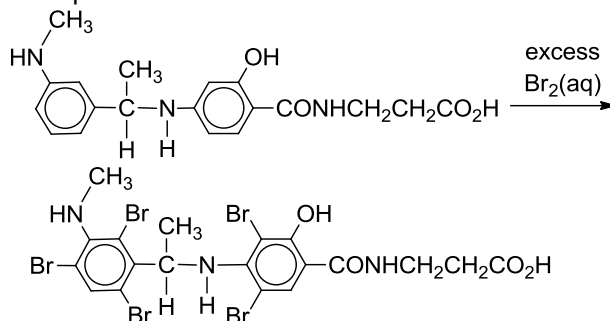
Molecules **I** and **II** are structural isomers of each other and are not stereoisomers.

Option 3: Incorrect

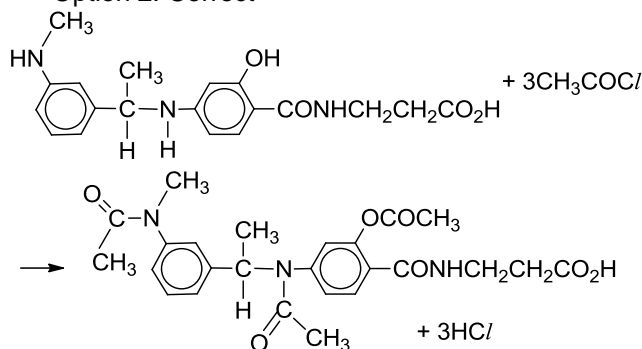
Molecules **I** and **II** are enantiomers, hence they are stereoisomers. The overall dipole moment of the two molecules are identical.

39 B (1 and 2 only are correct)

Option 1: Correct

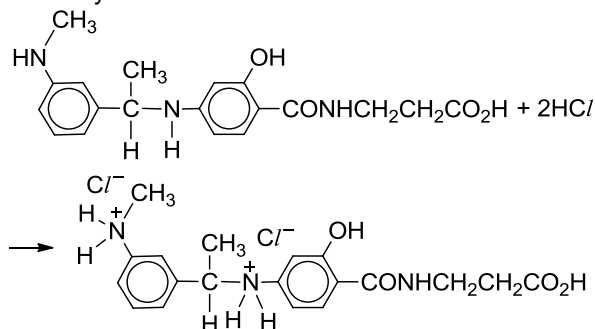


Option 2: Correct



Option 3: Incorrect

Only 2 mol of cold HCl would react with 1 mol of **T**.



40 D (1 only is correct)

Option 1: Correct

Option 2: Incorrect

The molecular formula is $\text{C}_{12}\text{H}_{18}\text{Br}_6$.

Option 3: Incorrect

The $\text{C}-\text{C}-\text{C}$ bond angles are all 109.5° as every C atom is sp^3 hybridised.

