INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY

9647/01

Paper 1 Multiple Choice

30 August 2016

1 hour

Additional Materials: Data Booklet
Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **16** printed pages and **0** blank page.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Carbon disulfide, CS_2, is a volatile liquid used in the production of cellophane which is used for food packaging.

On combustion, CS_2 is oxidised as follows.

$$CS_2(g) + 3O_2(g) \longrightarrow CO_2(g) + 2SO_2(g)$$

A 20 cm^3 sample of carbon disulfide vapour is ignited with 100 cm^3 of oxygen. The final volume of gas after burning is treated with an excess of aqueous alkali.

Which percentage of this final volume dissolves in alkali? (All volumes are measured at room temperature of pressure.)

A 20%

B 40%

C 60%

D 80%

Answer: C

1 mole of CS_2 reacts with 60cm^3 of O_2, remaining volume of O_2 = 40 cm^3

produces 1 mole of CO_2

20 cm^3 of CS2 produces 20 cm^3 of CO_2 and 40 cm^3 of SO_2

Total volume of gases at the end of reaction = 40 + 20 + 40 = 100 cm^3

Both CO_2 and SO_2 are acidic gases which will react with NaOH

Hence % of final volume dissolved in alkali 60/100 x 100% = 60%

2 Consider the following half-equations

$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$$
$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$
$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

What volume of 0.01 mol dm^{-3} potassium manganate(VII) is needed to completely oxidise 25.0 cm^3 of an acidified solution of 0.01 mol dm^{-3} FeC_2O_4?

A 5 cm^3

B 7.5 cm^3

C 10 cm^3

D 15 cm^3

Answer: D

Combining eqns:

$$FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2 + 3e^- \quad x5$$

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O \quad x3$$

Overall equation: $3MnO_4^- + 5FeC_2O_4 \longrightarrow 10CO_2 + 5Fe^{3+} + 3Mn^{2+} + 12H_2O$

Amount of FeC_2O_4= 25/100 x 0.01 = 0.00025 mol
Mole ratio of FeC_2O_4 : MnO_4^- = 5 : 3
Amount of MnO_4^- = 3/5 x 0.00025 = 0.00015 mol
Volume of MnO_4^- = 0.00015 / 0.01 = 0.015 dm^3 = 15 cm^3

3 Which electronic configuration represents an element that forms a simple ion with a charge of – 3?

A $1s^22s^22p^63s^23p^1$

B $1s^22s^22p^63s^23p^3$

C $1s^22s^22p^63s^23p^63d^14s^2$

D $1s^22s^22p^63s^23p^63d^34s^2$

Answer: B

A : Group III element : + 3 ion

B: Group V : – 3 ion

C and D are transition elements – forms positively charged ions

4 Carbon dioxide is a gas at room temperature while silicon dioxide is a solid because

A carbon dioxide contains double covalent bonds while silicon dioxide contains single covalent bonds.

B instantaneous dipole – induced dipole attractions are weaker than permanent dipole – permanent dipole attractions.

C carbon-oxygen bonds are less polar than silicon-oxygen bonds.

D van der Waals' forces are much weaker than covalent bonds.

Answer D
Carbon dioxide is a simple molecules with weak can der waal's forces of attraction between molecules while silicon dioxide is a giant covalent structure with strong covalent bonds. Thus, less amt of energy is required to overcome the weaker VDW forces of attraction between CO_2 molecules, resulting in lower boiling point.

5 Under which conditions will the behaviour of a gas be **most** ideal?

	pressure	temperature
A	high	high
B	high	low
C	Low	high
D	Low	low

Answer: C
Gas behave most ideally at high temperatures and low pressures.

At high temperatures, particles have sufficient energy to overcome the intermolecular forces of attraction.

At low pressures, particles are very far apart. The volume of the particles is negligible to the volume of container which they moves in; intermolecular forces of attraction is negligible.

6 The enthalpy changes involving some oxides of nitrogen are given below:

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\Delta H = +180$ kJ mol^{-1}

$2NO_2(g) + \frac{1}{2}O_2(g) \rightarrow N_2O_5(g)$ $\Delta H = -55$ kJ mol^{-1}

$N_2(g) + \frac{5}{2}O_2(g) \rightarrow N_2O_5(g)$ $\Delta H = +11$ kJ mol^{-1}

What is the enthalpy change, in kJ mol^{-1}, of the following reaction?

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

A –114 **B** +114 **C** –136 **D** +136

Answer: A

Reverse Equation 1: $2NO(g) \rightarrow N_2(g) + O_2(g)$ $\Delta H = -180$ kJ mol^{-1}

Reverse Equation 2: $N_2O_5(g) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$ $\Delta H = +55$ kJ mol^{-1}

Equation 3 remains: $N_2(g) + \frac{5}{2}O_2(g) \rightarrow N_2O_5(g)$ $\Delta H = +11$ kJ mol^{-1}

Sum up these 3 equations: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\Delta H = -180+55+11$
$= -114$ kJ mol^{-1}

7 A typical protein forms hundreds of hydrogen bonds and thousands of van der Waals' forces in folding from primary to tertiary structures.

Which of the following thermodynamic state functions of the protein best represents the folding process?

	ΔG / kJ mol^{-1}	**ΔH / kJ mol^{-1}**	**ΔS / J K^{-1} mol^{-1}**
A	–	–	–
B	+	–	+
C	–	+	–
D	+	+	–

Answer: A

When hydrogen bonds and van der Waals' forces are formed, heat will be released. Thus ΔH is negative.

When the protein is folded from primary to tertiary structures, the system becomes less disordered. Thus ΔS is negative.

The process of protein folding is spontaneous. Thus, ΔG is negative.

8 When 1 mole of carbon dioxide gas solidifies as dry ice, 25.2 kJ of heat energy is evolved. The sublimation temperature of carbon dioxide is –78.5 °C.

What is the entropy change when 132 g of carbon dioxide gas solidifies at this temperature?

A +130 J K^{-1}

B –130 J K^{-1}

C +389 J K^{-1}

D –389 J K^{-1}

Answer: D

This is a phase change reaction. $\Delta G = 0$

$\Delta G = \Delta H - T\Delta S$

$$\Delta S = \frac{\Delta H - \Delta G}{T}$$

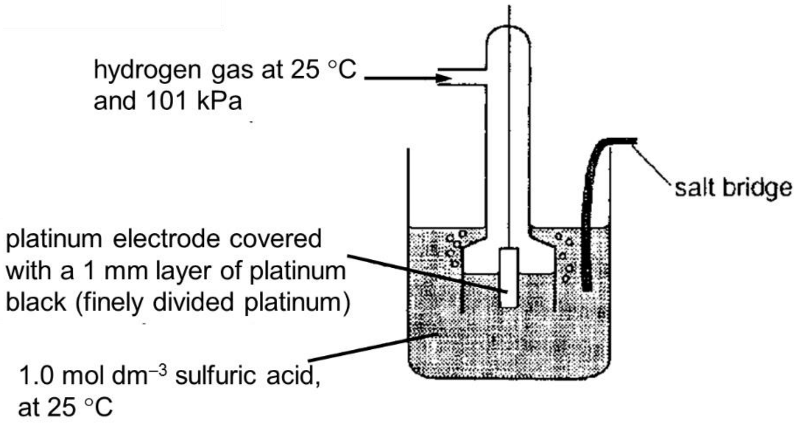
$$\Delta S = \frac{-25200 - 0}{-78.5+273}$$

$$\Delta S = \frac{-25200}{194.5}$$

$\Delta S = -129.56$ J K^{-1}

ΔS when 132 g of carbon dioxide gas solidifies $= -129.56 \times \frac{132}{44} = -389$ J K^{-1}

9 A student set up the hydrogen electrode shown in the diagram below.



What would have to be changed to make this a standard hydrogen electrode?

A the acid solution used

B the temperature of the gas and of the acid solution

C the pressure of the gas

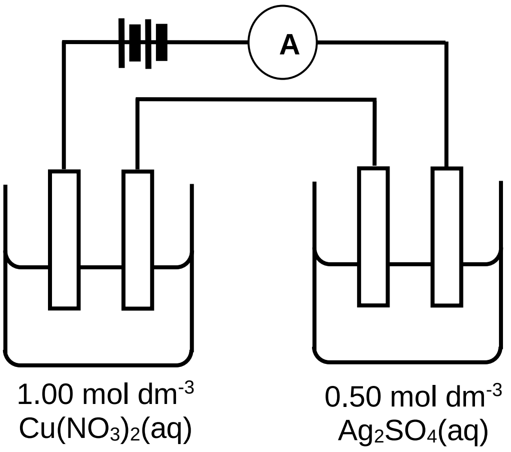
D the metal comprising the electrode

Answer:A

In 1.0 mol dm^{-3} sulfuric acid, [H$^+$] = 2.0 mol dm^{-3}. To make the electrode a standard hydrogen electrode, either change the acid to a 1.0 mol dm^{-3} monoprotic acid (option **A**), or halve the concentration of sulfuric acid used.

10 *Use of the Data Booklet is relevant to this question.*

Using inert electrodes, a current was passed through two beakers containing aqueous silver sulfate and aqueous copper(II) nitrate, connected in series under standard conditions.



At 25^{o}C, 1 atm

What is the ratio of the mass of silver to copper deposited after the current was passed for *t* minutes?

A	0.59	**B**	0.85
C	1.70	**D**	3.40

Answer: D

$It = n_eF$

$$n_e \text{ transferred} = \frac{It}{F}$$

$Cu^{2+} + 2e^- \rightarrow Cu$

$$n_{Cu} = \frac{It}{2F}$$

$Ag^+ + e^- \rightarrow Ag$

$$n_{Ag} = \frac{It}{F}$$

$$\frac{\text{mass of Ag formed}}{\text{mass of Cu formed}} = \frac{\text{Ar x no. of moles of Ag formed}}{\text{Ar x no. of moles of Cu formed}} = \frac{108 \text{ x } \frac{It}{F}}{63.5 \text{ x } \frac{It}{2F}} = 3.40$$

11 A nitrogen-hydrogen mixture, initially in the mole ratio of 1:3, reached equilibrium with ammonia when 50% of the nitrogen had reacted. The total equilibrium pressure was *p*.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

What was the partial pressure of ammonia in the equilibrium mixture?

A $\frac{p}{3}$ **B** $\frac{p}{4}$ **C** $\frac{p}{6}$ **D** $\frac{2p}{7}$

Ans A

	$N_2(g)$	+ $3H_2(g)$	$\rightleftharpoons$	$2NH_3(g)$
Initial amt	x	3x		
Change	x/2	3x/2		x
Eqm amt	x/2	3x-3x/2		x

Total final pressure = sum of eqm partial pressure = x/2 + (3x-3x/2) + x = p

3x = p → x = p/3

12 Solid calcium hypochlorite pellets, $Ca(ClO)_2(s)$, are added to swimming pools to form $HClO(aq)$, which kills disease-causing bacteria and algae.

$$Ca(ClO)_2(s) \;\square\; Ca^{2+}(aq) + 2ClO^-(aq)$$

$$ClO^-(aq) + H_2O(l) \;\square\; HClO(aq) + OH^-(aq)$$

What is the effect on the solubility of calcium hypochlorite and bacterial growth when pH decreases?

	Solubility of calcium hypochlorite	Effect on bacterial growth
A	decreases	more favourable
B	decreases	less favourable
C	increases	more favourable
D	increases	less favourable

Answer: D

When pH decreases, $[H^+]$ increases and $[OH^-]$ decreases, equilibrium position of second equation shift to the right and $[HClO]$ increases. Bacterial growth will be **less favourable**.

When $[ClO^-]$ decreases, equilibrium position of first equation shift to the right and **solubility of calcium hypochlorite increases**.

13 The dissociation constant, K_w, for the ionisation of water, $H_2O \rightleftharpoons H^+ + OH^-$, at different temperatures is given below.

temperature / °C	K_w
0	1.15×10^{-15}
25	1.00×10^{-14}
50	5.50×10^{-14}

What can be deduced from this information?

A Only at 25 °C are $[H^+]$ and $[OH^-]$ equal.

B The equilibrium lies furthest to the right at 0°C.

C The forward reaction is exothermic.

D The pH of water decreases as temperature increases.

Answer: D

Option A is wrong as $[H^+]$ and $[OH^-]$ are equal at all temperature for pure water.

Option B is wrong as the equilibrium lies furthest to the right at 50°C (as shown by K_w value).

Option C is wrong as the forward reaction is endothermic. When temperature increases, K_w increases. This shows that equilibrium lies to the right.

Option D is correct as the forward reaction is endothermic. When temperature increases, K_w increases. This shows that equilibrium lies to the right. $[H^+]$ increases and this leads to decrease in pH.

14 A sparingly soluble salt, $Mg_3(PO_4)_2$ dissociates in aqueous solution as follows:

$$Mg_3(PO_4)_2 \rightleftharpoons 3\,Mg^{2+} + 2\,PO_4^{3-}$$

Given that the solubility product, K_{sp} of $Mg_3(PO_4)_2$ is $\boldsymbol{Q}$, what is the value of $[Mg^{2+}]$ in a saturated solution?

A $(\frac{9Q}{4})^{\frac{1}{5}}$

B $(\frac{Q}{27})^{\frac{1}{3}}$

C $(\frac{Q}{108})^{\frac{1}{5}}$

D $(\frac{9Q}{64})^{\frac{1}{3}}$

Answer: A

	$Mg_3(PO_4)_2$ $\rightleftharpoons$	$3\,Mg^{2+}$ +	$2\,PO_4^{3-}$
Change	– x	+ 3x	+ 2x
Equilibrium		3x	2x

$K_{sp} = [Mg^{2+}]^3\,[PO_4^{3-}]^2$

$Q = (3x)^3\,(2x)^2$

$Q = (27x^3)\,(4x$

$x = (\frac{Q}{108})^{\frac{1}{5}}$

$[Mg^{2+}] = 3 \times (\frac{Q}{108})^{\frac{1}{5}}$

$= (\frac{243Q}{108})^{\frac{1}{5}}$

$= (\frac{9Q}{4})^{\frac{1}{5}}$

15. The reaction of hydrogen peroxide with iodide ions in an acidic solution is first order with respect to hydrogen peroxide as well as iodide ions, and zero order with respect to hydrogen ions.

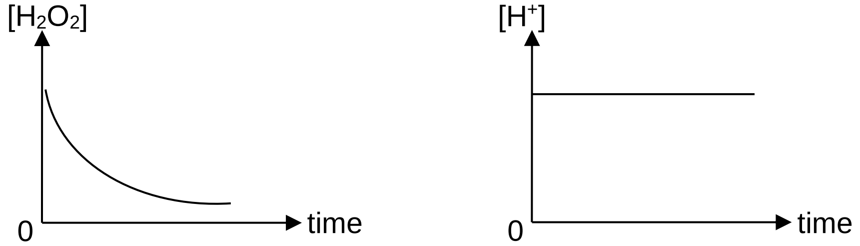
$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

Two experiments were carried out. Which pair of diagrams represents the variation of $[H_2O_2]$ and $[H^+]$ with time?

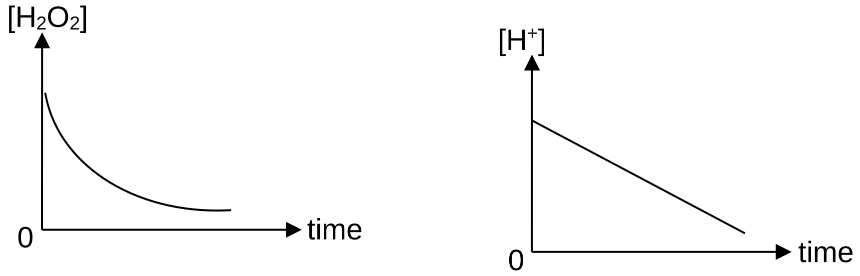
Experiment 1: In the presence of excess I^-

Experiment 2: In the presence of excess I^- and H_2O_2

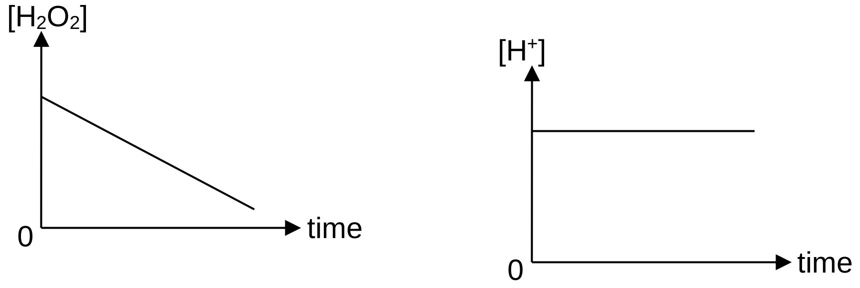
A



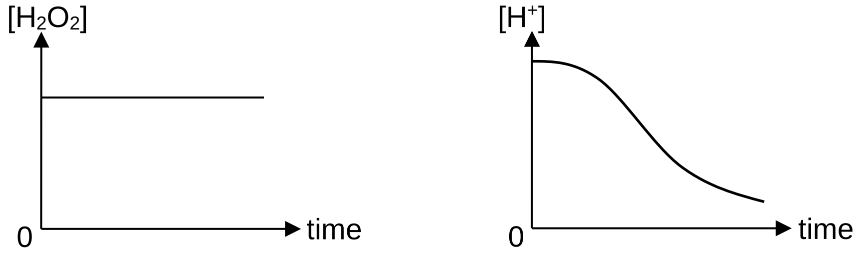
B



C



D



Ans B

Given in question: Rate = k$[H_2O_2][I^-]$,

For expt 1: $[I^-]$ is first order

The graph of $[H_2O_2]$ against time is a downward sloping curve with decreasing gradient.

Rate = k'$[H_2O_2]$ where k' = k$[I^-]$

For expt 2:

$[H+]$ is zero order. The graph of $[H^+]$ against time is a decreasing straight line with a constant gradient.
Rate = k' where k' = k$[I^-][H_2O_2]$

16 Aluminium is an element in the third period, Na to Ar, of the Periodic Table.

What is true for aluminium?

A Aluminium has the highest melting point of the elements in this period.

B Aluminium is the only element in this period whose chloride reacts with water to form an acidic solution

C Aluminium is the only element in this period which can exist, at room temperature and pressure, as solid and conduct electricity.

D Aluminium is the only element in this period whose oxide reacts with both acids and bases.

Answer: D

Period 3 trends

Aluminium is the only amphoteric oxide in third period.

17 Which of the following statements regarding Group II elements or their compounds is **correct**?

A Magnesium chloride has a higher melting point than barium chloride.

B Magnesium is a stronger reducing agent than strontium.

C Calcium hydroxide is more thermally stable than barium hydroxide.

D Strontium reacts more readily with oxygen than radium.

Answer:

$MgCl_2$ has a larger magnitude of lattice energy than $BaCl_2$ since ionic radius of Mg^{2+} is smaller than that of Ba^{2+} ion.

Mg is a weaker reducing agent or undergoes oxidation less readily than Sr since $E^\ominus(Mg^{2+}/Mg)$ is less negative than $E^\ominus(Sr^{2+}/Sr)$.

$Ca(OH)_2$ is less thermally stable than $Ba(OH)_2$ as Ca^{2+} has a higher charge density than Ba^{2+} (due to the smaller ionic radius of Ca^{2+}. Ca^{2+} polarises the electron cloud of OH- ions and weakens the O-H bond in the hydroxide ions to a greater extent, thus less energy is required for the decomposition of $Ca(OH)_2$.

The reactivity of Group II metals increases down the group due to increasing reducing power of the metals down the Group. Since Sr is above Ra in Group II, Sr is expected to react less readily with oxygen than Ra.

18 Which of the following statements about astatine, the element below iodine in Group VII of the periodic table, is **incorrect**?

A Silver astatide is insoluble in aqueous ammonia.

B Hydrogen astatide is less stable to heat than hydrogen iodide.

C Sodium astatide and hot concentrated sulfuric acid react to form astatine.

D Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.

Answer:

AgI is insoluble in both dilute and concentrated NH_3 and since Ksp of AgX decreases down the group, AgAt is expected to be less soluble in both dilute and concentrated NH_3 than AgI.

H-At bond is weaker than H-I bond since At atom is bigger and more diffuse leading to less effective orbital overlap in H-At bond.

Since reducing power of the halides increases down the group and NaI reacts with conc H_2SO_4 to give I_2, NaAt is similarly expected to react with conc H_2SO_4 to give I_2.

At_2 cannot undergo displacement reaction with KCl since At_2 is a weaker oxidising agent (or less likely to undergo reduction) than Cl_2 as oxidising power of halogen decreases down the group.

19 When copper(II) chloride is dissolved in water it gives a blue solution. When this solution is treated with an excess of concentrated hydrochloric acid it turns yellow.

What are the formulae of the copper species in the blue and yellow solution?

	blue	yellow
A	$CuCl_2$	$[CuCl_4]^{2-}$
B	$CuCl_2(H_2O)_4$	$[CuCl_6]^{4-}$
C	$Cu(OH)_2$	$CuCl_2(H_2O)_4$
D	$[Cu(H_2O)_6]^{2+}$	$[CuCl_4]^{2-}$

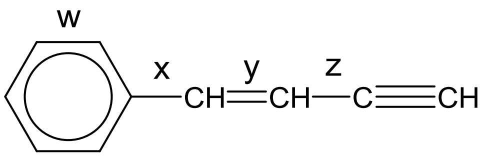
Answer: D

When copper(II) chloride dissolves in water, it dissociates into Cu^{2+} and Cl^- ions. The Cu^{2+} ions exist in the hydrated form, $[Cu(H_2O)_6]^{2+}$, which is blue in colour.

When excess conc HCl is added, ligand exchange occurs, where the Cl^- ligand displace the H_2O ligands to form $[CuCl_4]^{2-}$, according to the following equation.

$$[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6\,H_2O$$

20 Four carbon-carbon bonds are labelled in the diagram.



Which bonds are made up of an sp^2–sp^2 overlap?

A w and y only

B w, x and y only

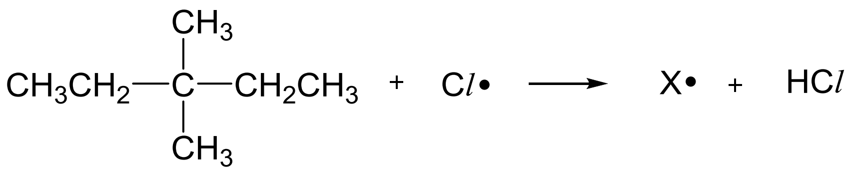
C w, x, y and z

D x and y only

Answer: B

All the carbons are sp2, except the bond for z where the carbon in C≡C is sp hybridized.

21 When heated with chlorine, the hydrocarbon 3,3-dimethylpentane undergoes free radical substitution. In the propagation step, the free radical **X•** is formed by the loss of one hydrogen atom.



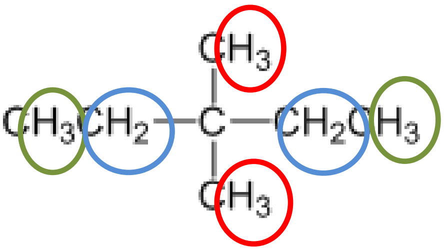
$$CH_3CH_2-C(CH_3)_2-CH_2CH_3 + Cl\bullet \longrightarrow X\bullet + HCl$$

How many different forms of **X•** are theoretically possible?

A 2 **B** 3 **C** 4 **D** 5

Answer: B

There are 3 types of Hydrogen atoms that can be lost.



22 Bromoethene, $CH_2{=}CHBr$, is unreactive to nucleophiles whereas 3-bromopropene, $CH_2{=}CHCH_2Br$ is very reactive by comparison.

What explains the lack of reactivity of $CH_2{=}CHBr$?

A Substituted alkenes undergo only electrophilic addition.

B The C=C double bond and the Br atom are both electron withdrawing which stabilises $CH_2{=}CHBr$.

C The electrons on the Br atom delocalise into the π bond.

D The presence of the π bond prevents free rotation of the C-Br bond this decreasing the reactivity.

Answer: C

For halogen-containing organic compounds, reactivity to nucleophiles (such as OH-) depends on the bond strength of C-X bonds. The unreactivity of bromoethene with nucleophile possibly suggest stronger C-Br bonds, as a result of the p orbital of Br overlapping with π bonds, hence having partial double-bond character.

23 Phosgene, $COCl_2$, is a colourless gas that gained infamy as a chemical weapon during World War I. It is formed when trichloromethane, $CHCl_3$, is left exposed to the atmosphere.

Below is a reaction scheme that involves trichloromethane and phosgene:

$$CHCl_3 \longrightarrow COCl_2 \longrightarrow COCl(OH) \longrightarrow CO_2 + HCl$$

Which of the following type of reaction is **not** being observed in the reaction scheme?

A Oxidation

B Elimination

C Electrophilic addition

D Nucleophilic substitution

Ans: C

$$CHCl_3 \xrightarrow[\text{Oxidation}]{} COCl_2 \xrightarrow[\text{nucleophilic substitution}]{} COCl(OH) \xrightarrow[\text{elimination}]{} CO_2 + HCl$$

24 A chlorine-containing organic compound, **X**, undergoes an elimination reaction when treated with hot ethanolic potassium hydroxide solution.

What is **X**?

A CH_2Cl_2

B C_2Cl_6

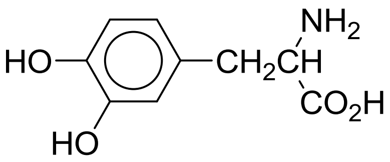
C $(CH_3)_2CHCH_2Cl$

D $(CH_3)_3CCH_2Cl$

Answer: C

To undergo elimination, there must be a hydrogen atom on the carbon atom adjacent to the carbon atom bearing the halogen atom. Only option C fulfils this criterion.

25 Dopamine is an important organic chemical that helps control the brain's reward and pleasure centres. It also helps regulate movement and emotional responses.



Dopamine

Which of the following statements about dopamine is **incorrect**?

A It is able to rotate plane-polarized light.

B It is soluble in water due to zwitterion formation.

C It migrates to the negative electrode of an electrolytic cell at pH 14.

D The acidity of dopamine will increase when aqueous bromine is added.

Ans: C

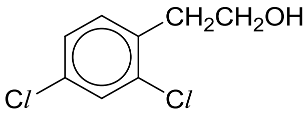
Option A: Dopamine indeed contains a chiral carbon and exhibits optical activity

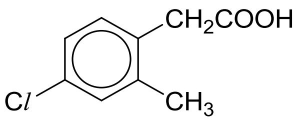
Option B: Dopamine is able to exist as a zwitterion RCH(NH3$^+$)(COO$^-$) which is able to form ion-dipole interactions with water.

Option C: At pH 14, the COOH group is deprotonated. The predominant form is the anionic form, which should migrate to the positive electrode instead of the negative electrode.

Option D: When aqueous bromine is added, electrophilic substitution occurs with the introduction of Br into the benzene ring. Br is electron withdrawing and is able to disperse the negative charge on the oxygen atoms in the anion, thus increasing the acidity of the compound.

26 Two bottles containing the following reagents had their labels removed.





Which one of the following reagents can be used to distinguish between them?

A sodium metal

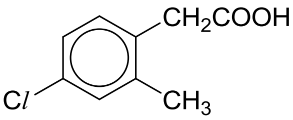
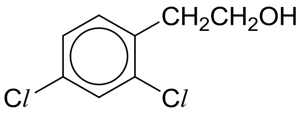
B sodium hydroxide

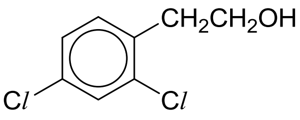
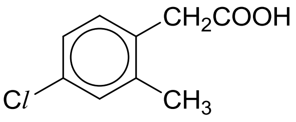
C hot acidified potassium manganate(VII)

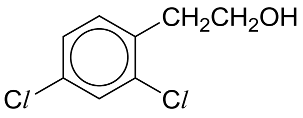
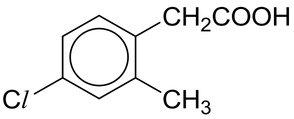
D hot acidified potassium dichromate

Ans: **D**

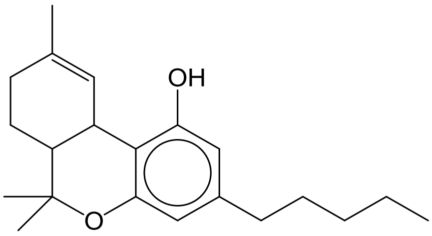
Option A: Both compounds react with Na. Effervescence will be seen for both compounds. Gas evolved will extinguish lighted splint with a ‘pop’ sound.

Option B:  can react with NaOH but not . However, the reaction is not easily visible.

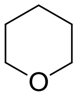
Option C: Both  and  reacts with hot acidified KMnO$_4$ via side chain oxidation. Hence purple KMnO$_4$ will decolourise for both compounds and effervescence will be seen for both. Gas evolved will form white ppt with Ca(OH)$_2$.

Option D:  reacts with hot acidified $K_2Cr_2O_7$ via oxidation of primary alcohol (orange solution turns green).  does not undergo side chain oxidation as $K_2Cr_2O_7$ is a weaker oxidizing agent than $KMnO_4$.

27 Marijuana (cannabis) is the most widely used illegal drug in many developed countries. Medical studies have shown that the active ingredient in marijuana, tetrahydrocannabinol, might provide medical benefits to some patients.



tetrahydrocannabinol

In the following reactions, the  remains unaltered.

Which reaction will tetrahydrocannabinol undergo?

A It reacts with aqueous bromine to incorporate up to 2 atoms of bromine in each molecule.

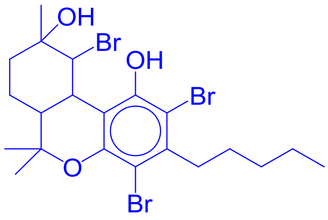
B It reacts with hot acidified potassium dichromate(VI) to form a green solution.

C It reacts with dilute nitric acid to form a substitution product.

D It reacts with ethanoic acid to form a sweet-smelling product.

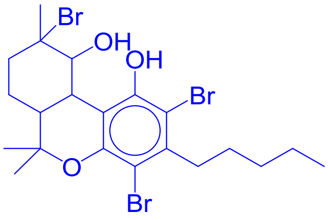
Ans: C

Option **A** is incorrect because both alkene group and phenol group will react with aqueous Br_2 to incorporate **3 Br atoms,** forming the following products:



(more major)

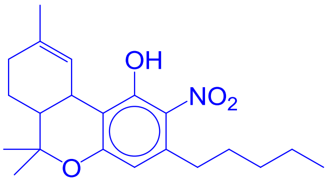
OR



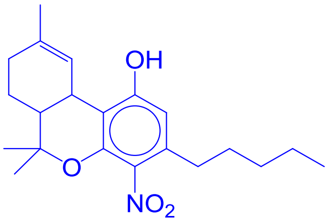
(less major)

Option **B** is incorrect. $K_2Cr_2O_7$ is not strong enough to oxidise side-chain of benzene and alkene. Phenol is not oxidised as well.

Option **C** is correct. Dilute nitric acid reacts with phenol functional group via electrophilic substitution to form the following product:



Or



Option **D** is incorrect. Phenol functional group does not react readily with ethanoic acid (even in the presence of conc. H_2SO_4 as catalyst). Hence, no ester will be formed. (To form the ester, the phenol should be treated with aq. NaOH to generate a stronger phenoxide ion before added into ethanoyl chloride)

28 A student carried out an experiment to study the ease of hydrolysis of a series of chlorinated compounds, and recorded the observations based on the addition of acidified silver nitrate solution.

Which of the following gives the expected results?

	time taken for precipitate to appear			
	shortest	→		longest
A	C_6H_5Cl	$CH_2ClCONH_2$	CH_3COCl	$COCl_2$
B	$CH_2ClCONH_2$	C_6H_5Cl	$COCl_2$	CH_3COCl
C	CH_3COCl	$COCl_2$	C_6H_5Cl	$CH_2ClCONH_2$
D	$COCl_2$	CH_3COCl	$CH_2ClCONH_2$	C_6H_5Cl

Ans: D

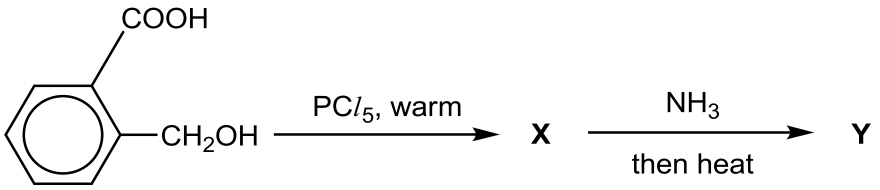
$COCl_2$ and CH_3COCl more reactive as the highly electronegative O and Cl atoms that are bonded to acyl carbon make it more electron deficient (or more δ+ charged), thus attract nucleophiles more readily. $COCl_2$ hydrolyses more rapidly than CH_3COCl as the former has its acyl carbon more electron deficient due to its additional Cl atom.

In addition, the acyl carbon atoms are sp^2 hybridised, so they have trigonal planar arrangement with respect to C, resulting in less steric hindrance for the approach of nucleophiles compared to the sp^3 C atom (that is bonded to Cl in $CH_2ClCONH_2$).

$CH_2ClCONH_2$ is the next most reactive as the C atom bonded to only one highly electronegative Cl atom is less electron deficient (or less δ+ charged) compared to $COCl_2$ and CH_3COCl.

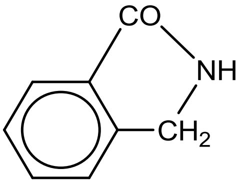
C_6H_5Cl is a halogenoarene (or aryl halide) where its Cl atom is bonded directly to benzene ring. The p orbital of Cl overlaps with the π electron cloud of benzene ring resulting its lone pair being delocalized into benzene and double bond character in its C-Cl bond. Since its C-Cl is most difficult to break, nucleophilic substitution (or hydrolysis) cannot occur.

29 In the following two-step synthesis, **Y** a solid which is insoluble in water, is one of the components in the final reaction mixture.

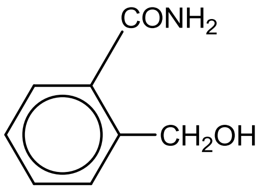


What is **Y**?

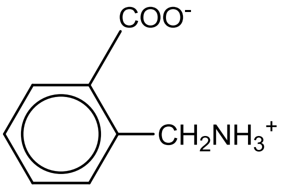
A



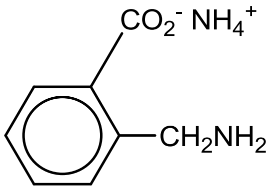
C



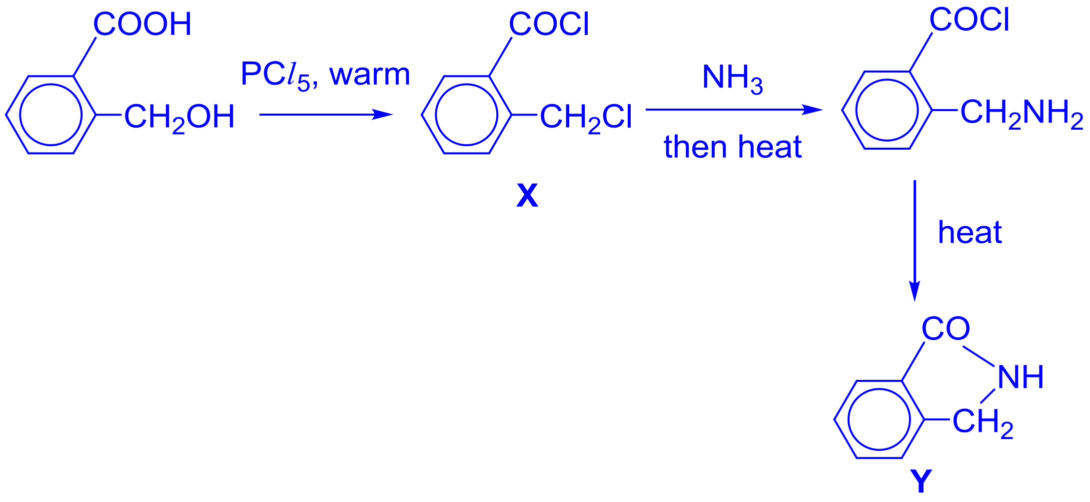
B

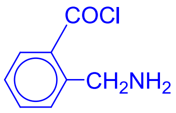


D



Ans: A



The reaction of X with NH_3 produces a mixture of products.  is one of the products which contains an amine group and an acyl chloride group. The amine group is nucleophilic and undergo intramolecular reaction with the electron-deficient C of the acyl chloride to form a cylic product.

Since reaction with PCl_5 converts –COOH to –COCl and –CH_2OH to –CH_2Cl (as shown in **X**), the product should not contain –COO- or –CH_2OH group. Hence, by elimination of options, B, C and D are incorrect.

30 Benzylamine has the formula $C_6H_5CH_2NH_2$ and is a common precursor in organic synthesis.

Which of the following statements about benzylamine is correct?

A It decolourises aqueous Br_2.

B It can be produced by reduction of $C_6H_5CH_2CN$.

C It reacts with CH_3COOH to form $C_6H_5CH_2NHCOCH_3$.

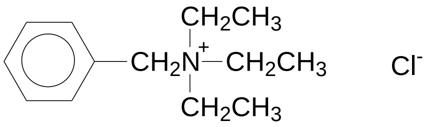
D It reacts with excess CH_3CH_2Cl to form the compound, $C_{13}H_{22}NCl$.

(A) $-CH_2NH_2$ group is not strongly activating, hence benzylamine, $C_6H_5CH_2NH_2$, cannot undergo easy electrophilic substitution with aqueous Br_2. This is not to be confused with phenylamine, $C_6H_5NH_2$.

(B) When $C_6H_5CH_2CN$ undergoes reduction, $C_6H_5CH_2CH_2NH_2$ is produced, not $C_6H_5CH_2NH_2$.

(C) $C_6H_5CH_2NH_2$ undergoes acid base reaction, not condensation reaction, with CH_3COOH to give $C_6H_5CH_2NH_3^+CH_3COO^-$. An amide is formed from condensation between a primary or secondary amine and *acyl halide*.

(D) A quaternary ammonium salt (shown below) is formed from successive nucleophilic substitutions (polyalkylation).



Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	**B**	**C**	**D**
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 Gaseous particle **Y** has a proton(atomic) number *n* and a charge of +1.

Gaseous particle **Z** has a proton(atomic) number of *n+1* and is isoelectronic with **Y**.

Which statement correctly describes **Y** and **Z**?

1 **Y** has a larger radius than **Z**.

2 **Y** requires more energy than **Z** when a further electron is removed from each particle.

3 **Y** releases more energy than **Z** when an electron is added to each particles.

Ans: D

Statement 1 (correct) Y (less protons) and isoelectronic with Z has a lower nuclear charge and has a larger radius.
Statement 2: (wrong) Z has a higher nuclear charge and hold electrons more strongly(stronger attraction) and hence requires more energy.

32 Which of the following molecules will form a hydrogen bond with another of its own molecules?

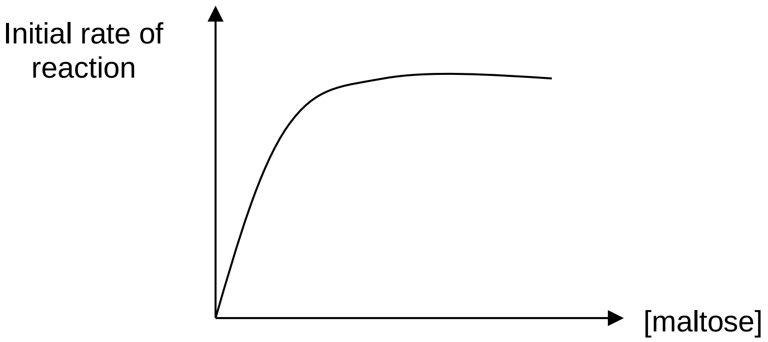
1 CH_3NH_2

2 CH_3CHO

3 CH_3CH_2F

Answer: D
Option 1: There is H-bonding between CH_3NH_2.
Option 2: No H-bonding as O is not directly bonded to H atom.
Option 3: No H-bonding as F is not directly bonded to H atom.

33 The graph below shows the results of an investigation of the initial rate of hydrolysis of maltose by the enzyme amylase. In the experiments, the initial concentration of maltose was varied but that of amylase was kept constant.



Which conclusions can be deduced from these results?

1 When [maltose] is low, the rate is first order with respect to [maltose].

2 When [maltose] is high, the rate is independent of [maltose].

3 When [maltose] is high, the rate is independent of [amylase].

Answer: B
Answer: B

Option 1:
At **low substrate concentration[**maltose**]**, not all of the active sites are occupied.

- rate ∝ [maltose] ⇒ reaction is **first order** with respect to the maltose.

Option 2:
At **high [**maltose**]**, all the active sites are occupied, i.e. the active sites of the enzyme [amylase] become **saturated** with maltose.

- Any increase in [maltose] will not have any effect on the reaction rate.
- The reaction is **zero order** with respect to the maltose.

Option 3: If substrate is not the limiting factor, increasing enzyme amylase concentration **will increase** the rate of reaction, as there will be more active sites of enzyme.

34 With reference to the *Data Booklet* and the data below, deduce which of the following statements are correct.

Half-equation	E^{θ}**/V**
$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l)$	+1.00
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l)$	+0.34
$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq) + H_2O(l)$	-0.26

1 An excess of zinc is capable of reducing $VO_2^+(aq)$ to $V^{2+}(aq)$ in acidic conditions.

2 $Fe^{3+}(aq)$ is capable of oxidising $V^{2+}(aq)$ to VO_2^+ (aq) in acidic conditions.

3 $Zn^{2+}(aq)$ ions will oxidise $V^{2+}(aq)$ ions to $V^{3+}(aq)$ ions.

Answer: D

Answer: D

Half-equation	**E^{θ}/V**
$Zn^{2+} + 2e^{-} \rightarrow Zn$	–0.76

Option 1:

Excess Zn is the reducing agent which can reduce VO_2^{+}(aq) to VO^{2+}(aq)

Ecell = +1.00 – (–0.76) =1.76V > 0

Excess Zn can further reduce VO^{2+}(aq) to V^{3+}(aq) :

Ecell = +0.34 – (–0.76) = 1.10V >0

Excess Zn can further reduce $V^{3+}(aq) + e^{-} \rightarrow V^{2+}(aq)$:

Ecell: –0.26 – (–0.76) = 0.50V > 0

Quick thinking for MCQ:
Since Ecell = Ered – Eoxi > 0 for reaction to proceed (Zn is oxidised),
Ered – (–0.76) > 0
Ered > – 0.76 for reaction to proceed

Option 2: wrong
Quick thinking for MCQ:
Since Ecell = Ered – Eoxi > 0 for reaction to proceed
(Fe^{3+} is reduced to Fe^{2+}),
+0.77 – Eoxi > 0
Eoxi < + 0.77 for reaction to proceed

Fe^{3+} can oxidise V^{2+} to VO^{2+} but not VO_2^{+}

$VO_2^{+}(aq) + 2H^{+}(aq) + e^{-} \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$Fe^{3+} + e^{-} \rightarrow Fe^{2+}$	+0.77

Ecell = +0.77 – 1.00 = –0.23v < 0

Another factor: Fe^{3+} is not in excess, successive oxidation of vandadium compounds may not occur.

35 The working range and colour change of Chlorophenol red is given below.

Indicator	Working pH range	Colour change	
		Acid	Alkali
Chlorophenol red	4.8 – 6.4	Yellow	Red

Two drops of this indicator are added to each of the three aqueous solutions listed below.

Which solution has its colour correctly stated?

	Solution	Colour
1	Aluminium oxide added to water	Red
2	0.1 mol dm^{-3} of CH_3COOH (K_a= 1.8 x 10^{-5} mol dm^{-3})	Yellow
3	Solution of sodium ethanoate and ethanoic acid in 1:2 proportion [pK_a of ethanoic acid = 4.7]	Orange

Answer: B

Option 1 is correct.
Aluminium oxide does not dissolve in water and it gives a pH 7 solution. According to the working pH range of this indicator, the color is red.

Option 2 is correct.

$$[H^+] = \sqrt{K_a[\text{acid}]}$$

$$= \sqrt{1.8X10^{-5}[0.1]}$$

$$= 1.342 \times 10^{-3} \text{ mol dm}^{-3}$$

$$\therefore \text{pH} = -\log_{10}(1.342 \times 10^{-3}) = \underline{2.87}$$

According to the working pH range of this indicator, the color shown for a solution of pH 2.87 is yellow.

Option 3 is incorrect.

$$\text{pH} = \text{p}K_a + \log \frac{[salt]}{[acid]} = 4.7 + \log 0.5 = 4.7 - 0.3 = 4.4$$

According to the working pH range of this indicator, the color shown for a solution of pH 4.4 is yellow and not orange.

36 *Use of the Data Booklet is relevant to this question*.

Which statements about the trends in properties of the hydrogen halides are correct?

1 Volatility decreases in the order: HF > HC*l* > HBr > HI.

2 Thermal stability increases in the order: HI < HBr < HC*l* < HF.

3 Ease of oxidation increases in the order: HF < HC*l* < HBr < HI.

Ans: C

Option 1: Volatility is inversely proportional to the boiling point. The higher the boiling point, the less volatile the substance. HF has stronger intermolecular hydrogen bonding that requires more energy to break while the strength of instantaneous dipole-induced dipole interaction increases from HCl to HBr to HI due to increasing polarizability of electron cloud of the molecules. Thus the correct trend of volatility is HF < HI < HBr < HCl.

Option 2: Thermal stability of hydrogen halides depend on the bond strength of H-X. The stronger the H-X bond, the more thermally stable the hydrogen halides. Down the group, the valence orbital is more diffused, as there is less effective orbital overlap between the valence orbitals of hydrogen and halogen OR down the group, as the atomic size of halogen increases, the H-X bond length increases. As such, the H-X bond strength is weaker, and less thermally stable. Therefore, the trend of increasing thermal stability (HI < HBr < HC*l* < HF) is correct.

Option 3: The ease of oxidation or reducing power of the halides increases down the group due to the less positive $E^\ominus(X_2/X^-)$ down the group. Hence, the trend is correct.

37 Nickel is purified by a method called the Mond process. The equation of the first step of the purification is shown below.

$$Ni(s) + 4CO(g) \longrightarrow Ni(CO)_4(l)$$

Which of the following statements are correct?

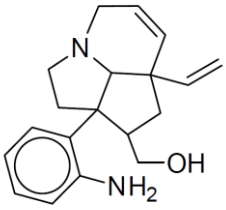
1 CO is a monodentate ligand.

2 Ni in $Ni(CO)_4$ has a co-ordination number of 4.

3 The oxidation number of Ni in $Ni(CO)_4$ is zero.

Ans: A
CO is a monodentate ligand as it forms one dative bond (using the lone pair of electron on the carbon atom) per formula unit.
Ni in $Ni(CO)_4$ has 4 dative or coordinate bonds formed with 4 CO ligands, thus its coordination number is 4.
Since the charges of the complex compound, $Ni(CO)_4$ and CO ligands are zero, the charge of Ni is zero too.

38 Compound **X** is a synthetic precursor of *meloscine*, an alkaloid isolated from the New Caledonian plant *Melodinus Scandens Forst*.



compound X

Which of the following statements about its reactions are correct?

1 1 mol of **X** reacts with 2 mol of HBr(g) when heated.

2 1 mol of **X** reacts with 4 mol of Br_2(aq) at room temperature.

3 1 mol of **X** reacts with 2 mol of CH_3COCl at room temperature.

Ans: C
Option 1: Incorrect. 1 mol of X reacts with 3 mol of HBr.
Each C=C will undergo electrophilic addition with HBr. 1° alcohol will undergo nucleophilic substitution with HBr, heat.

Option 2: Correct
Each C=C will undergo electrophilic addition with Br_2(aq). Phenylamine will undergo electrophilic substitution with 2 mol of Br_2 to form the di-substituted product.

Option 3: Correct
1° alcohol will undergo condensation reaction with CH_3COCl to form an ester. Phenylamine will undergo condensation reaction with 1 mol of CH_3COCl to form amide.

39 Which of the following reactions give products that **does not** rotate the plane of polarised light?

1 1–bromobutane refluxed with aqueous KOH

2 Butanone reacted with HCN, trace amount of NaOH

3 But–1–ene reacted with bromine dissolved in organic solvent

Ans: A
Option 1: 1-bromobutane is a 1° halogenoalkane hence it will react with aq KOH via S_N2 mechanism. Since the product does not contain a chiral carbon, it is unable to rotate plane of polarised light.

Option 2: Butanone reacts with HCN via nucleophilic addition. As the nucleophiles can attack the carbonyl carbon (trigonal planar in shape) either from the top or the bottom of the plane with equal chance, it results in a racemic mixture Hence, even though the products are chiral, they are unable to rotate plane of polarised light.

Option 3: But-1-ene reacts with bromine via electrophilic addition. As the electrophile can attack the C atom of the carbocation intermediate is trigonal planar in shape, either from the top or the bottom of the plane with equal chance, it results in a racemic mixture Hence, even though the products are chiral, they are unable to rotate plane of polarised light.

40 Which of the following could result in the loss of the tertiary structure of a protein?

1 Addition of weak acid

2 Addition of alcohol

3 Addition of $AgNO_3$ solution

Ans: A
Note: The tertiary structure of proteins refers to the 3D arrangement of the protein due to the folding of a polypeptide chain. Folding is due to R group (side chain) interactions.

Option 1: Addition of weak acid pH can change the ionic charges on amino acid residues (i.e. groups containing acidic COOH or basic NH_2 groups) and hence disrupt the ionic interactions.

⇒ In acidic conditions), protonation occurs, i.e. $–COO^-$ is converted to –COOH.

Option 2: Alcohol can disrupt the original hydrogen bonds between polar R groups thereby disrupting their normal folding.

Option 3: Metal ions (Ag^+) are positively charged cations. They compete with positively charged groups (e.g. $–NH_3^+$) for attraction to negatively charged groups (e.g. $-COO^-$), hence disrupting the original ionic interactions.

1	C	**6**	A	**11**	A	**16**	D	**21**	B	**26**	D	**31**	D	**36**	C
2	D	**7**	A	**12**	D	**17**	A	**22**	C	**27**	C	**32**	D	**37**	A
3	B	**8**	D	**13**	D	**18**	D	**23**	C	**28**	D	**33**	B	**38**	C
4	D	**9**	A	**14**	A	**19**	D	**24**	C	**29**	A	**34**	D	**39**	A
5	C	**10**	D	**15**	B	**20**	B	**25**	C	**30**	D	**35**	B	**40**	A

A = 10
B = 6
C = 9
D = 15