

$$K_{sp} \text{ of AgBr} = [\text{Ag}^+][\text{Br}^-]$$

N08-Paper 1 – MCQ

BACDC CADAC

DCDDA CBCAB

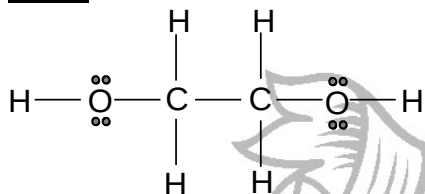
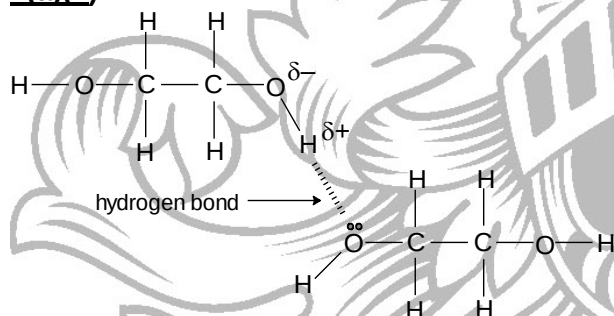
CAACC BCCCD

BDBBD CABCA

$$K_{sp} \text{ of AgBr} = [\text{Ag}^+][\text{Br}^-]$$

$$= (7.1 \times 10^{-7})(7.1 \times 10^{-7})$$

$$= \underline{5.0 \times 10^{-13} \text{ mol}^2 \text{ dm}^{-6}}$$

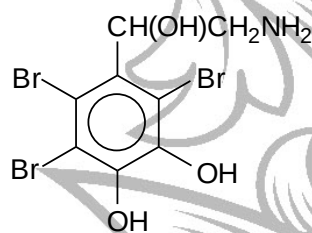
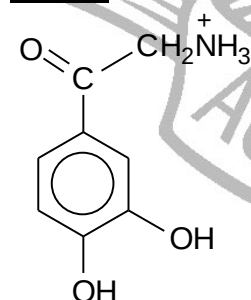
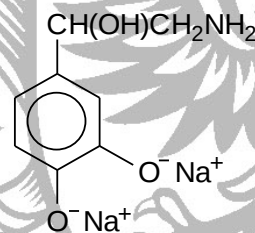
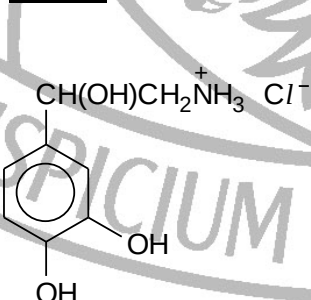
N08-Paper 2 – Structured Questions**1(a)(i)****1(a)(ii)****1(b)(i)**

Ethene

1b(ii)Decolourisation of purple $\text{KMnO}_4(\text{aq})$.**1(c)**

The three functional groups are:

- secondary alcohol,
- phenol and
- primary amine.

1(d)(i)**1(d)(iii)****1(d)(ii)****1(d)(iv)****2(b)(i)**

For AgCl,

$$\Delta G_{ppt}^\circ = 2.303RT \log K_{sp}$$

$$= (2.303)(8.31)(298)(\log 2.0 \times 10^{-10})$$

$$= -5.53 \times 10^4 \text{ J mol}^{-1}$$

$$= \underline{-55.3 \text{ kJ mol}^{-1}}$$

2(b)(ii)

$$\Delta G_{ppt}^\circ = \Delta H_{ppt}^\circ - T\Delta S_{ppt}^\circ$$

$$T\Delta S_{ppt}^\circ = \Delta H_{ppt}^\circ - \Delta G_{ppt}^\circ$$

$$\Delta S_{ppt}^\circ = [-66.0 - (-55.3)]/298$$

$$= -0.0359 \text{ kJ mol}^{-1} \text{ K}^{-1}$$

$$= \underline{-35.9 \text{ J mol}^{-1} \text{ K}^{-1}}$$

2(b)(iii)

The negative sign indicates that entropy of the system decreases. The entropy decreases because of the formation of an ordered solid lattice.

2(c)

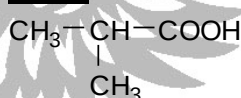
For AgF,

$$\Delta G_{ppt}^\circ = 2.303RT \log K_{sp}$$

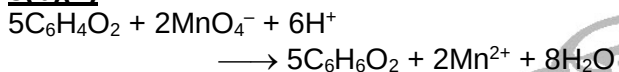
$$= (2.303)(8.31)(298)(\log 1.006)$$

$$= \underline{+14.8 \text{ J mol}^{-1}}$$

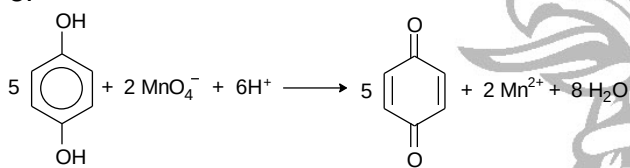
Since $\Delta G_{ppt}^\circ > 0$, precipitation of AgF does not occur i.e. AgF is soluble in water at 298 K.

3(a)(i)**3(a)(ii)****3(b)(i)**

$$E_{cell}^\circ = 1.52 - 0.70 = \underline{+0.82 \text{ V}}$$

3(b)(ii)

or

**3(b)(iii)**

$\text{H}_2(\text{g})$ would reduce quinone to quinol.

This is because the $E^\ominus$ for



is less positive than +0.70 V.

Alternative answer: $\text{SO}_2(\text{g})$

3(c)

LiAlH_4 in dry ether

Alternative answer: NaBH_4

3(d)(i)

Reagent: 2,4-dinitrophenylhydrazine

Quinone will react to produce an orange precipitate.

3(d)(ii)

Reagent: Na

Quinol will react to produce effervescence of H_2 that gives a 'pop' sound with a lighted splint.

Or

Reagent: neutral $\text{FeCl}_3(\text{aq})$

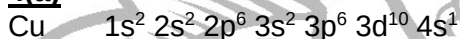
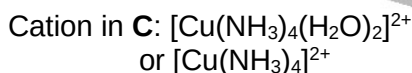
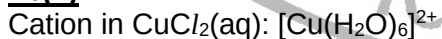
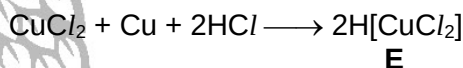
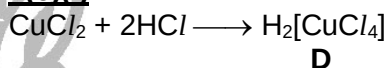
Quinol will react to produce a violet/purple solution.

3(d)(iii)

Reagent: $\text{Br}_2(\text{aq})$

For quinone, decolourisation of brown $\text{Br}_2(\text{aq})$ will occur.

For quinol, decolourisation of brown $\text{Br}_2(\text{aq})$ and formation of a white precipitate will be observed.

4(a)**4(b)(i)****4b(ii)****4(c)(i)****4(c)(ii)**

Complex ion in **D**: $[\text{CuCl}_4]^{2-}$

Complex ion in **E**: $[\text{CuCl}_2]^-$

4(c)(iii)

ligand exchange

4(c)(iv)

D is tetrahedral in shape.

Also accepted: square planar

4(c)(v)

+1

4(d)(i)

reduction

4(d)(ii)

CuCl

4(e)(i)

Molar ratio of Cu to F to K

$$= \frac{21.5}{63.5} : \frac{38.7}{19.0} : \frac{39.8}{39.1}$$

$$= 0.338 : 2.036 : 1.018$$

$$= 1 : 6 : 3$$

Empirical formula of **G**: K_3CuF_6

4(e)(ii)

+3

4(f)(i)

Both **E** and **F** contain $\text{Cu}(\text{I})$.

$\text{Cu}(\text{I})$ does not have any empty or partially-filled d orbitals.

Consequently d-d transitions are not possible and hence both **E** and **F** are colourless.

4(f)(ii)

G contains $\text{Cu}(\text{III})$ which has electronic configuration $1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 3\text{d}^8$.

There are partially filled 3d orbitals. Consequently d-d transitions are possible giving rise to colour observed for **G**.

N08-Paper 3 – Free Response Questions

1(a)

The bond energy of a X–Y bond is the average amount of energy required to break one mole of the X–Y bonds in the gas phase.

1(b)(i)

The reaction can be carried out by inserting a hot wire (or glass rod) into a test tube containing the gas or by heating.

(Note: mention of a catalyst here is incorrect.)

1(b)(ii)

The extent of the given decomposition reaction increases down the group.

1(b)(iii)

$$\Delta H = 2BE(H-X) - BE(X-X) - BE(H-H)$$

For X = Cl,

$$\Delta H = (2)(431) - 436 - 244 = +182 \text{ kJ mol}^{-1}$$

For X = I,

$$\Delta H = (2)(299) - 436 - 151 = +11 \text{ kJ mol}^{-1}$$

1(b)(iv)

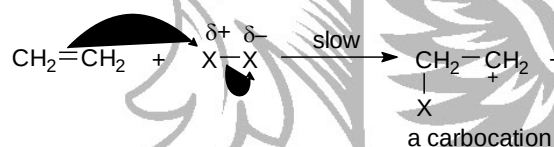
The decomposition reaction becomes less endothermic down the group. Hence the extent of the reaction increases down the group.

1(c)

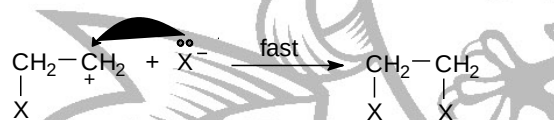
Type of reaction: electrophilic addition

Mechanism:

Step 1: Formation of carbocation



Step 2: Formation of addition product



1(d)(i)

The boiling point increases from $\text{CH}_3\text{CH}_2\text{Cl}$ to $\text{CH}_3\text{CH}_2\text{I}$. This is due to increasing strength of instantaneous dipole-induced dipole interactions arising from increasing number of electrons from $\text{CH}_3\text{CH}_2\text{Cl}$ to $\text{CH}_3\text{CH}_2\text{I}$.

1(d)(ii)

The C–X bond polarity decreases from $\text{CH}_3\text{CH}_2\text{Cl}$ to $\text{CH}_3\text{CH}_2\text{I}$. This is because of decreasing electronegativity value from Cl to Br to I.

1(d)(iii)

The reactivity towards nucleophilic reagents increases from $\text{CH}_3\text{CH}_2\text{Cl}$ to $\text{CH}_3\text{CH}_2\text{I}$. This is due to decreasing strength of the C–X bond from X = Cl to X = I.

1(e)

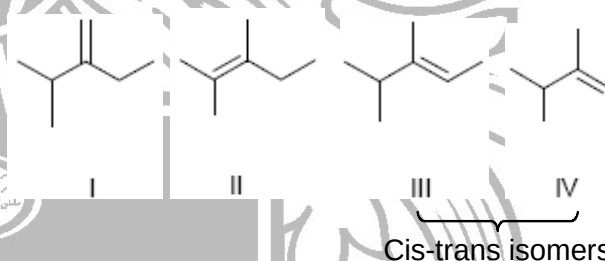
P is a tertiary alkyl bromoalkane with the following structure:



Note:

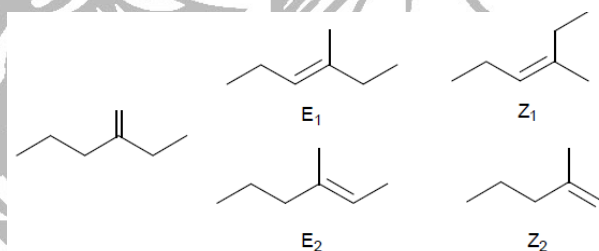
Q is the corresponding tertiary alcohol (i.e. –Br being replaced by –OH), which is resistant to oxidation by acidified $\text{K}_2\text{Cr}_2\text{O}_7$.

The four alkenes are as shown below.



Note:

P cannot be since such a bromoalkane produces five alkenes, shown below, upon undergoing elimination.



2(a)

Products at the cathode: NaOH(aq) and H₂(g)

Anode: $2R-CO_2^- \longrightarrow R-R + 2CO_2 + 2e^-$

Cathode: $2H_2O + 2e^- \longrightarrow 2OH^- + H_2$

Overall equation:

**2(b)**

Quantity of charge passed = current x time
 = (2.0)(40 x 60)
 = 4800 C

Amount of electrons = 4800/96500
 = 0.04974 mol

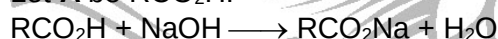
Amount of ethane = $(\frac{1}{2})(0.04974)$
 = 0.02487 mol

Molar mass of ethane = 30.0 g mol⁻¹

Mass of ethane produced = (0.02487)(30.0)
 = 0.746 g

2(c)

Let **A** be RCO₂H.



Amount of NaOH = (11.4/1000)(0.100)
 = 1.14 x 10⁻³ mol

Amount of RCO₂H = 1.14 x 10⁻³ mol

Molar mass of **A** = 0.100/(1.14 x 10⁻³)
 = 87.7 g mol⁻¹

Hence **A** is either CH₃CH₂CH₂CO₂H or (CH₃)₂CHCO₂H.

(Note: you are asked for a structure hence the molecular formula C₃H₇CO₂H is not accepted.)

2(d)

Assume **C** is an ideal gas and apply the ideal gas equation.

$$pV = nRT$$

$$n = \frac{pV}{RT}$$

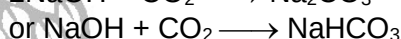
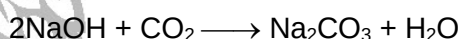
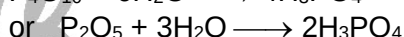
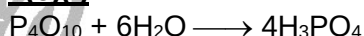
$$= \frac{(1.01 \times 10^5)(87 \times 10^6)}{(8.31)(380)}$$

$$= 2.783 \times 10^{-3} \text{ mol}$$

Mass of 2.783 x 10⁻³ mol of **C** = 0.20 g

M_r of **C** = $\frac{0.20}{2.783 \times 10^{-3}} = 71.8$

Since **C** is an alkane,
C has molecular formula, C₅H₁₂.

2(e)(i)**2(e)(ii)**

Mass of H₂O = 1.55 g

Amount of H₂O = $\frac{1.55}{18.0} = 0.0861 \text{ mol}$

Mass of CO₂ = 3.03 g

Amount of CO₂ = $\frac{3.03}{44.0} = 0.0689 \text{ mol}$

2(e)(iii)

Molar ratio of C to H

= Amount of C : Amount of H
 = 0.0689 : (2)(0.0861)
 = 2 : 5

Hence empirical formula of **D** is C₂H₅.

Molecular formula of **D** is C₄H₁₀.

Note: molecular formula of **D** is verified by checking that the number of moles of **D**:CO₂ is indeed (1.00/58.0) : 0.0689 = 1:4.

2(f)

Acid **A**:

CH₃CH₂CH₂CO₂H
 or (CH₃)₂CHCO₂H

Alkane **C**: C₅H₁₂.

Alkane **D**: C₄H₁₀.

Analysing the number of carbons,

C ≡ R-R' **D** ≡ R'-R'

Hence **E** must be a symmetrical alkane R-R

Acid **A** has a 3-carbon alkyl group

⇒ Acid **B** has a 2-carbon alkyl group

Hence acid **B** is CH₃CH₂CO₂H.

Alkane **C** is formed from acid **A** and acid **B**.

Alkane **D** is formed from acid **B**.

⇒ alkane **E** is formed from acid **A**.

Hence alkane **E** has molecular formula C₆H₁₄

and can be CH₃(CH₂)₄CH₃

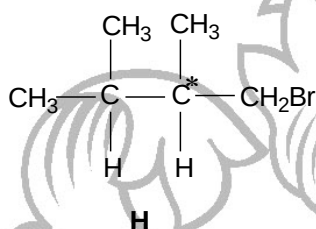
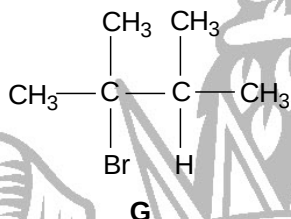
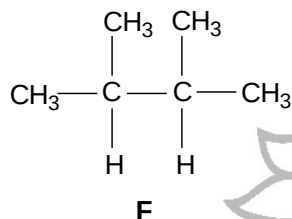
or (CH₃)₂CHCH(CH₃)₂.

2(a)

F, C_6H_{14} , underwent free radical substitution with Br_2 under ultraviolet light, to produce only two isomeric monobromo compounds **G** & **H**.
 $\Rightarrow$ **F** contains only two types of H atoms.

Compound **H** was chiral.

$\Rightarrow$ **H** has a chiral carbon atom.



* denotes chiral carbon atom

3(a)(i)

HCN and catalytic amount of KCN(aq)

Or

HCN and catalytic amount of KOH(aq)

3(a)(ii)

HCl(aq), heat

3(b)

Let lactic acid be denoted by HA.



At equilibrium, $[H^+] = [A^-]$

and assume $[HA] = \text{initial } [HA] = 0.20 \text{ mol dm}^{-3}$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$[H^+] = (K_a [HA])^{1/2} = [(1.38 \times 10^{-4})(0.20)]^{1/2} = 5.25 \times 10^{-3} \text{ mol dm}^{-3}$$

$$pH = -\lg(5.25 \times 10^{-3}) = 2.28$$

3(c)(i)

A buffer solution is one which is able to resist change in pH upon the addition of a small amount of an acid or a base.

3(c)(ii)

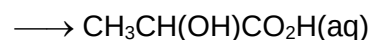
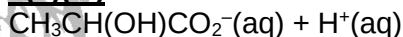
$[\text{acid}] = [\text{lactic acid}] = 0.20 \text{ mol dm}^{-3}$

$[\text{salt}] = [\text{lactate}] = 0.30 \text{ mol dm}^{-3}$

For this acidic buffer,

$$pH = pK_a + \lg \frac{[\text{salt}]}{[\text{acid}]}$$

$$\begin{aligned}
 &= -\lg(1.38 \times 10^{-4}) + \lg \left(\frac{0.30}{0.20} \right) \\
 &= 3.86 + 0.18 \\
 &= 4.04
 \end{aligned}$$

3(c)(iii)**3(d)(i)**

ester

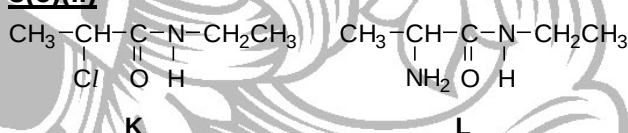
3(d)(ii)

hydrolysis

3(e)(i)

(1) NaOH(aq), heat

(2) HCl(aq), room temperature

3(e)(ii)

The Cl atom in the acyl chloride group is more reactive than the Cl atom in the chloroalkane group.

This is because the carbonyl carbon atom in the acyl chloride group has a larger partial positive charge since it is bonded to two electronegative atoms, O and Cl. Consequently this carbon atom attracts nucleophiles more readily.

Alternative answer:

- Trigonal planar shape with respect to the carbonyl carbon atom in the acyl chloride group $\Rightarrow$ sterically more open to nucleophilic attack
- Tetrahedral shape with respect to the carbon atom bonded to the Cl atom in the chloroalkane group $\Rightarrow$ sterically more hindered to nucleophilic attack

3(f)(ii)

Test (1)

Add 2,4-dinitrophenylhydrazine to each sample.

For M, an orange precipitate will be observed.

For N, there will be no orange precipitate.

Test (2)

Add Tollens' reagent to each sample and warm the mixture.

For M, a silver mirror will be observed.

For N, there will not be any silver mirror formed.

Alternative answers:

- Add Fehling's solution and warm
- Add $\text{Na}_2\text{CO}_3(\text{aq})$
- Add Na
- Add PCl_5

Molar mass of $\text{Mg}_3\text{N}_2 = 100.9 \text{ g mol}^{-1}$

Amount of $\text{Mg}_3\text{N}_2 = 2.0/100.9 = 1.98 \times 10^{-2} \text{ mol}$

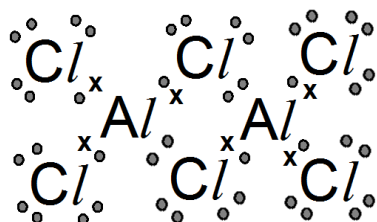
Amount of $\text{MgO} = (3)(1.98 \times 10^{-2})$
 $= 0.0594 \text{ mol}$

Molar mass of $\text{MgO} = 40.3 \text{ g mol}^{-1}$

Mass of MgO produced $= (0.0594)(40.3)$
 $= 2.39 \text{ g}$

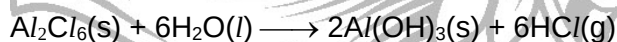
4(a)

Molecular formula of the vapour: Al_2Cl_6



4(b)

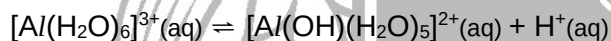
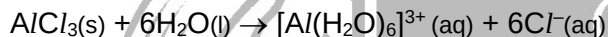
When only a few drops of water are added to the solid, steamy white fumes of HCl are evolved and together with the formation of $\text{Al}(\text{OH})_3$, a white solid, which is insoluble in water.



or



When a large amount of water is added to the solid, $[\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$ is formed.

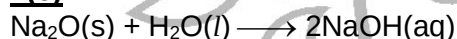


Due to the relatively high charge density of Al^{3+} ion, $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ undergoes hydrolysis to produce a weakly acidic solution.

Note:

- yellow-white solid can be denoted by AlCl_3 or Al_2Cl_6

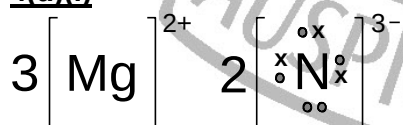
4(c)



$\text{Na}_2\text{O}(\text{s})$ dissolves to produce $\text{NaOH}(\text{aq})$ when it is added to a solution of litmus in water.

Due to the OH^{-} ions produced, the solution is alkaline and the litmus solution turns blue.

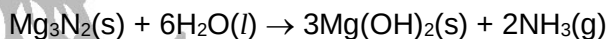
4(d)(i)



4(d)(ii)



Alternative answer:



Mass of $\text{Mg}(\text{OH})_2 = 3.47 \text{ g}$

4(e)(i)

Factors that affect the magnitude of the lattice energy of an ionic compound:

- (1) charges of the cation and anion
- (2) cationic radius and anionic radius

4(e)(ii)

The magnitudes of the lattice energies of Group 2 oxides decrease down the group due to increasing cationic radius of the Group 2 cation down the group.

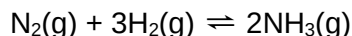
4(e)(iii)

N^{3-} has a greater charge than O^{2-} . This causes the magnitude of the lattice energy of Mg_3N_2 to be larger than that of MgO . This is despite the fact that the N^{3-} ion is larger than the O^{2-} ion.

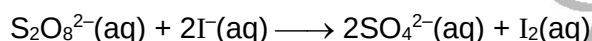
Note: In this case, the anionic charge is the more important factor.

5(a)

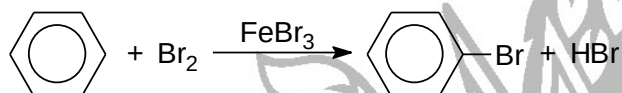
Any two of the following:



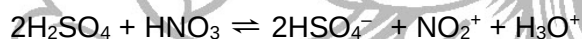
Fe acts as a heterogeneous catalyst in the above reaction.



$\text{Fe}^{3+}(\text{aq})$ acts as a homogenous catalyst in the above reaction.



FeBr_3 acts as a homogeneous catalyst in the above reaction.

5(b)**5(c)(i)**

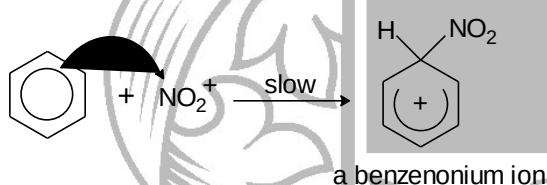
H_2SO_4 acts as a Bronsted-Lowry acid.

5(c)(ii)

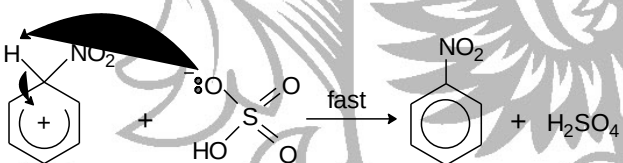
Type of reaction: electrophilic substitution

Mechanism:

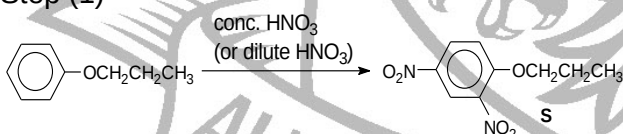
Step 1: Electrophilic attack by NO_2^+ on benzene



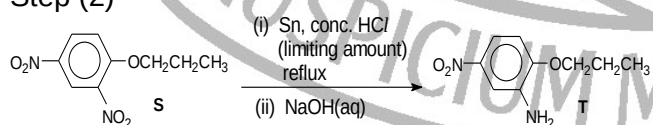
Step 2: Loss of proton to form product

**5(d)**

Step (1)



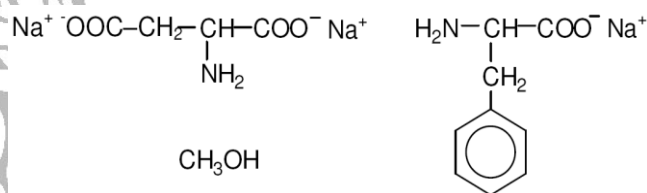
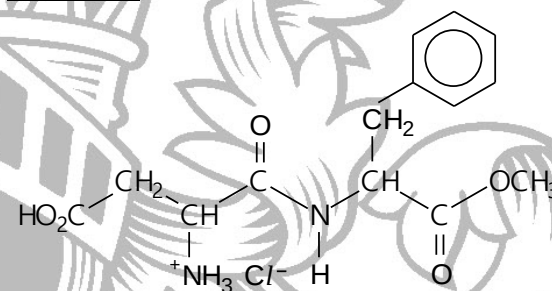
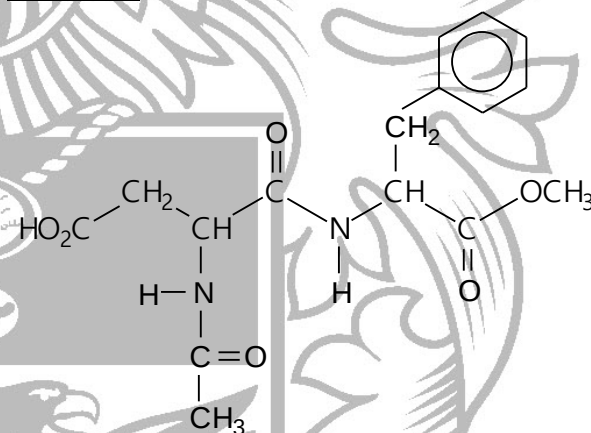
Step (2)

**5(e)(i)**

The four functional groups are: ester, carboxylic acid, primary amine and amide.

5(e)(ii)

The hydrolysis products are:

**5(e)(iii)(1)****5(e)(iii)(2)**

Suggested Solutions to N2008 H2 Chemistry Paper 1 (9746/01)

- 1 1 mol of any gas at rtp is 24 dm³. Hence amount of oxygen gas in 1 cm³ is $\frac{1}{24000}$ mol. The number of oxygen molecules will be this fraction multiplied by Avogadro's constant (6.02×10^{23}). Ans: **B**
- 2 The density of atmospheric nitrogen is higher than that of chemically pure nitrogen, which means there is an impurity in atmospheric nitrogen which is heavier than nitrogen itself. Argon is the only gas with a higher M_r than nitrogen. Ans: **A**
- 3 Option A: N, Option B: P, Option C: Sc, Option D: Mn.
Sc will form Sc³⁺ with a stable octet configuration. Though Mn³⁺ may also be formed, it requires more energy than forming Sc³⁺ (compare first 3 IEs of each element). Ans: **C**
- 4 The decomposition will lead to no change in the mass number, and an increase in 1 unit in the proton number. Option B is wrong because Ne is 1 proton less than the starting element Na. Ans: **D**

5

	Before losing an electron	After losing an electron
C ⁻	1s ² 2s ² 2p ³	1s ² 2s ² 2p ²
N	1s ² 2s ² 2p ³	1s ² 2s ² 2p ²
N ⁻	1s ² 2s ² 2p ⁴	1s ² 2s ² 2p ³
O ⁺	1s ² 2s ² 2p ³	1s ² 2s ² 2p ²

Ans: **C**

- 6 For N atoms 1 and 3, after forming 2 single bonds with 2 C atoms each, there are 3 electrons on the N atoms. Each N atom will then accept an electron from the Mg (which causes the Mg to be an ion) to form an octet configuration. Hence the bond is ionic. For N atoms 2 and 4, after forming 1 single bond and 1 double bond with 2 C atoms each, there is a lone pair of electrons on the N atoms, which allows them to form a dative bond to the Mg ion. Octet configuration is maintained. Ans: **C**

- 7 Let the initial pressure of NO₂ be p atm; let the change be y atm

2NO ₂ (g)	2NO(g)	O ₂ (g)
p	0	0
$-y$	$+y$	$+y/2$
$p - y$	y	$y/2$

Total final pressure = $p + y/2$

Hence $y/2$ is 20% of p , or $y = 0.4p$

Mole fraction of oxygen = $\frac{0.2p}{1.2p} = 0.17$ Ans: **A**

- 8 Copper has a giant metallic lattice of cations and a sea of delocalised electrons. Iodine has a simple molecular structure of iodine molecules with weak intermolecular forces of attraction. Ans: **D**

- 9 Enthalpy change of combustion is ALWAYS exothermic. Enthalpy change of solution can be either endothermic or exothermic. Formation of an ion from an element can be either endothermic (e.g. IE) or exothermic (e.g. first EA). Synthesis of a compound can be either endothermic or exothermic. Ans: **A**

- 10 Being an ice pack, the enthalpy change is endothermic. The dissolving of the salt is a process where the entropy change is positive since ions are now in solution and can move freely. Since the reaction occurs spontaneously the change in Gibbs free energy is negative. Ans: **C**

- 11 K_a only changes with temperature. Since the temperature is constant, K_a remains constant as volume changes. Ans: **D**

- 12 If the equilibrium constant is independent of temperature, it means the changing of the temperature will not favour the forward nor the reverse reaction (the change in forward rate constant k_f is the same in the backward rate constant k_b , such that $K_c = k_f/k_b$ remains constant). Hence enthalpy change of the reaction must be zero. Ans: **C**

- 13 After 80 days, the radioactive iodine would have undergone 10 half-lives. Hence $(\frac{1}{2})^{10}$ of the isotope will be left after that time. Ans: **D**

- 14 Amount of silver nitrate needed = $100/1000 \times 0.3 = 0.030$ mol = Amount of Cl⁻.

Ratio of chloride of **R** to silver nitrate used = 1:3 implies there are 3 chlorine atoms in the compound. The compound is a liquid at room temperature and fumes in air, therefore it must be PCl₃ (aluminium chloride is a solid and does not fume in air). Ans: **D**

15 Some of the barium hydroxide were 'lost' as barium carbonate and hence unable to take part in the titration. Therefore the volume of acid required is less. Option B and option D has no effect on the volume of acid used in the titration as the amount of OH⁻ ions remains constant. Option C will lead to a higher volume of acid used. Ans: **A**

16 Down group 17, the boiling point increases as the molecules become larger and there will be stronger intermolecular forces of attraction. The electron affinity decreases due to the increased shielding from additional layers of inner quantum shells, resulting in an increase in atomic size and hence weaker attraction for additional electron. Ans: **C**

17 Fe: 1s²2s²2p⁶3s²3p⁶3d⁶4s²; Fe²⁺: 1s²2s²2p⁶3s²3p⁶3d⁶

Remember to remove the 4s electrons before the 3d (conversely, fill up the 4s orbitals before the 3d). Ans: **B**

18 For the oxidation of Cr³⁺ to be feasible, the other species must have a reduction potential as positive as possible. Ans: **C**

A	$E^{\ominus}(\text{A}^{3+}/\text{A}) = -1.66 \text{ V}$
B	$E^{\ominus}(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$
C	$E^{\ominus}(\text{Fe}^{3+}/\text{Fe}^{2+}) = +0.77 \text{ V}$
D	$E^{\ominus}(\text{Zn}^{2+}/\text{Zn}) = -0.76 \text{ V}$

19 C2 and C3 are both sp² hybridised carbon atoms, where the hybrid orbitals have higher s orbital character and lower p orbital character than an sp³ hybrid orbital. Hence the sigma bond formed from the overlap of the sp² hybrid orbitals is shorter than that formed from sp³ hybrid orbitals (in ethane). Option **C** is wrong as the p orbitals in C2 and C3 are used in pi bond formation with C1 and C4 respectively and hence the electrons in them do not repel each other. Option **D** is wrong as there is no p-p overlap because all electrons of carbon are used in sigma bond formation. Ans: **A**

20 Option **B** uses free radical substitution, which will lead to many possible structural isomers and not give a good yield for the specific isomer. Ans: **B**

21 We consider the bonds broken for it makes up the activation energy for the reaction; the lower it is, the more likely the reaction proceeds. Ans: **C**

Option A: BE(C-H) = 410 kJ mol⁻¹;

Option B: BE(C-H) + BE(C-Cl) = 750 kJ mol⁻¹;

Option C: BE(C-Cl) = 340 kJ mol⁻¹;

Option D: BE(C-H) = 410 kJ mol⁻¹;

22 In order to have the CN group on both ends, compound **X** must have had halogen groups at the two terminals. Ans: **A**

23 None of the chlorine atoms will be removed by hydrolysis due to the partial double bond character in the C-Cl bond. Ans: **A**

24 The double end-ed free radical has the structure -CH₂-CH₂-O- hence the answer could be **B**, **C** or **D**. The remaining part of the formula must sum up to be an C₁₁ alcohol, thus **C** is the answer; **D** came from a carboxylic acid. *Green portion from alcohol, yellow portion from epoxyethane

A (CH₃(CH₂)₁₀O)₁₀CH₂CH₂OH – wrong as -CH₂CH₂O- missing

B CH₃(CH₂)₁₀O(OCH₂CH₂)₁₀OH – green portion does not sum up to C₁₁ alcohol

C CH₃(CH₂)₁₀O(CH₂CH₂O)₁₀H

D CH₃(CH₂)₁₀O(CH₂CH₂O)₁₀OH – green portion does not sum up to C₁₁ alcohol

Ans: **C**

25 Reagent **Y** is to dehydrate ethanol, forming ethene. Solution **Z** is to remove the excess reagent **Y** (acid) used. Ans: **C**

26 Options **A** and **C** requires heterogeneous catalyst such as Pt(s) whereas option **D** requires uv light or heat to generate the free radicals. Only Option **B** requires a homogeneous catalyst, such as NaCN(aq), to increase the the [CN⁻].

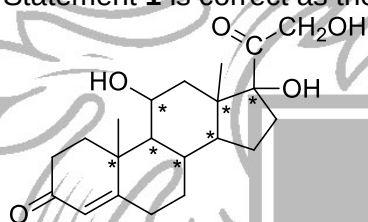
Ans: **B**

27 The phenolic group in option **C** will react with the ethanoyl chloride to form a phenyl ester. Ans: **C**

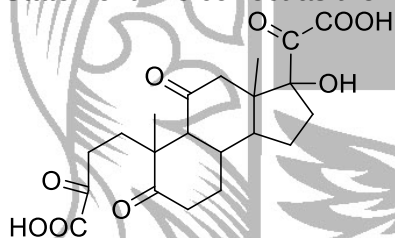
28 Upon acidic hydrolysis of the esters, only the alcohol (ethanol) formed in option **C** will give a positive iodoform test as it has the CH₃CH(OH)- group. Ans: **C**

29 At an acidic pH of 2, the amino acid will exist in the cationic form, with both the basic groups, i.e. -NH₂ groups protonated to form the positively charged -NH₃⁺. Ans: **C**

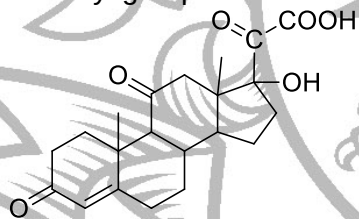
- 30 Only α -amino acids are involved in the building of proteins in the body. Option **D** is not an α -amino acid as its COOH and NH_2 groups are not on the same carbon. Ans: **D**
- 31 All three molecules are linear with C as the central atom. Electronegativity decreases down the group (Group 16 in this case), hence bond polarity decreases in the order $\text{C}=\text{O} > \text{C}=\text{S} > \text{C}=\text{Se}$. Ans: **B**
- 32 At 298K, carbon is in its solid state (statement 2 is wrong) and water is in its liquid state (statement 3 is wrong). Ans: **D**
- 33 The $\text{Fe}^{3+}/\text{Fe}^{2+}$ is the cathode (positive, +0.77V) and the S.H.E. is the anode (negative, 0 V), hence $E^\ominus_{\text{cell}}$ is +0.77 V. The solutions must contain 1.0 mol dm^{-3} of each ion, thus statement 3 is incorrect. Ans: **B**
- 34 Comparing expt 1 & 2, order of reaction wrt H_2O_2 is 1
Comparing expt 2 & 3, order of reaction wrt I^- is 1
Comparing expt 3 & 4, order of reaction wrt H^+ is 0
Using expt 1 and rate = $k [\text{H}_2\text{O}_2] [\text{I}^-]$, $k = 2 \times 10^{-2} \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$ Ans: **B**
- 35 Statement 2 is wrong because both ions have the same number of quantum shells as they are isoelectronic (same number of electrons). Statement 3 is wrong because electron repulsion affects ionization energy and not radius. Ans: **D**
- 36 The $E^\ominus$ values symbolises the tendency of the element to be reduced (or its oxidising power). Statement 1 is incorrect as there should be a decrease in oxidising power due to a decrease in $E^\ominus$ from X_2 to Z_2 . The calculated $E^\ominus_{\text{cell}}$ of statement 3 is $1.07 - 0.54 = +0.53 \text{ V}$, hence the reaction proceeds. Ans: **C**
- 37 From the diagram, the reaction is one-step. It involves the substitution of a halogen atom with an OH group. Hence the R-Hal undergoes $\text{S}_{\text{N}}2$ reaction. (refer to lecture notes on $\text{S}_{\text{N}}2$ reaction for halogen derivatives). Ans: **A**
- 38 Statement 1 is correct as there are 7 chiral centres.



Statement 2 is correct as the following structure is formed when hydrocortisone is oxidised.

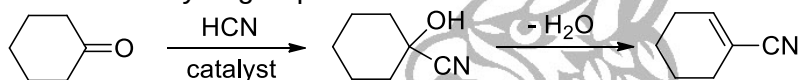


Statement 3 is wrong as upon oxidation with $\text{K}_2\text{Cr}_2\text{O}_7$ the final compound will only have 3 carbonyl groups.

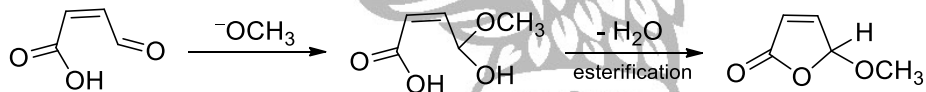


Ans: **B**

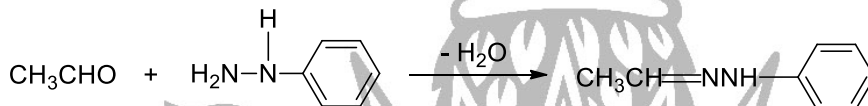
- 39 Statement 1 is wrong as the compound is formed from a cyclohexanone (a ketone) and not from an aldehyde group.



Statement 2 is correct.



Statement 3 is correct.



Ans: C

- 40 All three compounds are able to form cross-chain link (R-group interactions) to stabilise tertiary structure of protein.

Statement 1: Hydrogen bonding;

Statement 2: hydrogen bonding;

Statement 3: hydrogen bonding and VDW.

Ans: A