GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

JANUARY 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2013 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

GCE CHEMISTRY - CH1

JANUARY 2013 MARK SCHEME

SECTION A

Q.1 39 [1]

Q.2 C [1]

Q.3 $A_r = \frac{(12.0 \times 6) + (88.0 \times 7)}{100}$ (1) $= \frac{72.0 + 616.0}{100}$ = 6.88 (1) [2]

Q.4 (a) $\Delta H = \Delta H_2 + \Delta H_3 - \Delta H_1$ [1]

(b) $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g)$ state symbols requires [1]

Q.5 The position of equilibrium moves to the right / more COS is formed (1)
(By Le Chatelier's principle) the system 'removes' added 'material' to restore the position of equilibrium / accept explanation in terms of pressure (1) [2]

Q.6 Ti $\frac{60}{48}$ O $\frac{40}{16}$ (1)

= 1.25 = 2.5 ∴ 1 : 2

∴ TiO_2 (1) [2]

Section A Total [10]

SECTION B

Q.7 (a) (i) A helium (atom) nucleus / 2 protons and 2 neutrons / $^{4}He^{2+}$ [1]

(ii) b………22 (1) X…………..Ne (1) [2]

(iii) (4 × 2.6) = 10.4 [1]

(b) The frequency of the green line at 569 nm is HIGHER. than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm, this is caused by an electronic transition of HIGHER. energy than the line at 569 nm. [1]

(c) (i)

Na_2CO_3		$NaHCO_3$		$2H_2O$			
↓		↓		↓			
106	+	84	+	36	(1)	→	226 [1]

(or by other appropriate method – note mark is for the working)

(ii) Atom economy $= \dfrac{\text{'}M_r\text{ required product} \times 100}{\text{Total '}M_r\text{' of the reactants}}$ (1)

$= \dfrac{318 \times 100}{452} = 70.4 / 70.35\ (\%)$ (1) [2]

(iii) Carbon dioxide is produced (and released into the air) and this contributes to the greenhouse effect / increases acidity of sea (1)
It should be trapped / a use found for it. (1) [2]

(d) (i) Water is acting as a proton donor (1) and this combines with the carbonate ion / CO_3^{2-}, giving the hydrogencarbonate ion / HCO_3^- (1) [2]

(ii) The pH scale runs from 0-14 / measure of acidity / alkalinity (1)
pH <7 acid / >7 alkali (1)
acid stronger as pH value decreases / alkali stronger as pH value increases / 11.4 is strong alkali (1) [3]

Total [15]

Q.8 (a) (i) He may have lost carbon dioxide through leaks, this would have given a lower volume than expected. (1)
He used lower concentration of acid / diluted the acid with water and the rate of carbon dioxide evolution was slower than expected. (1) [2]

(ii) The concentration of acid is higher in the first half (1) the collision rate is higher (1) [2]

(iii) eg $k = \frac{V}{T}$ (1) $\therefore k = \frac{130}{298}$ / 0.436

$\therefore V = 0.436 \times 323 = 141$ (cm^3) (1)

or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ (1) $\therefore V_1 = \frac{323 \times 130}{298} = 141$ (cm^3) (1) [2]

(b) (i) 260 (cm^3) [1]

(ii) 0.45 (g) (0.43–0.48) [1]

(c) The diagram shows two reasonable distribution curves with T_2 flatter and 'more to the right' than T_1. (1)
Activation energy correctly labelled, or mentioned in the writing (1)
Fraction of molecules having the required activation energy is much greater at a higher temperature (thus increasing the frequency of successful collisions) (in words) (1) [3]

The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter QWC [1]

(d) Place the mixture on a balance and measure the (loss in) mass (1)
at appropriate time intervals (1)

OR BY OTHER SUITABLE METHOD

eg. sample at intervals / quench (1) titration (1) [2]

Total [14]

Q.9 (a) (i) They are both elements in their standard states. [1]

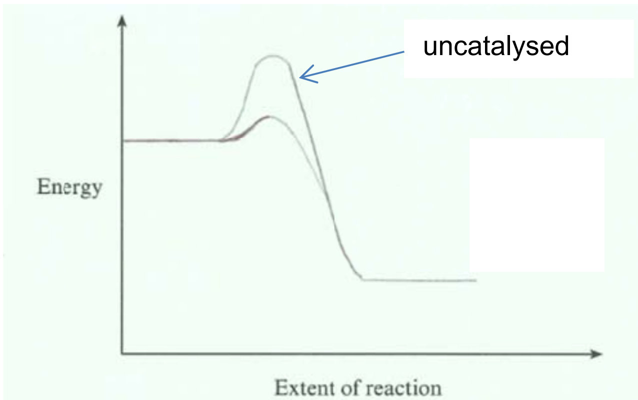
(ii) $\Delta H = \sum \Delta H_f$ products - $\sum \Delta H_f$ reactants (1)

$= (-286 + 0) - (-368 + 0)$

$= -286 + 368 = (+)82$ (kJ mol^{-1}) (1) [2]

or by a cycle where correct cycle drawn (1) correct answer (1)

(b) (i)



exothermic profile drawn (1)
uncatalysed / catalysed line labelled (1) [2]

(ii) I number of moles of benzene = 2000 [1]

II mole ratio is 1 : 1 (1)

$\therefore$ moles of phenol produced $= \dfrac{2000 \times 95}{100} = 1900$ (1)

mass = M_r × number of moles = 94 × 1900 = 178.6 / 179 kg (1)

alternatively

78 (g / kg) of benzene gives 94 (g / kg) of phenol (1)

$\therefore$ 1 (g / kg) of benzene gives 94/78 (g / kg) of phenol
$\therefore$ 156 (kg) of benzene gives 94 × 156/78 (kg) of phenol = 188 (kg) (1)
but 95% yield $\therefore$ $\dfrac{188 \times 95}{100} = 178.6 / 179$ (kg) (1) [3]

(iii) Look for at least four relevant positive points [4]

e.g.
- the process uses a (heterogeneous) catalyst, which can easily be separated from the gaseous products (thus saving energy)
- the only other product of the reaction is gaseous nitrogen, which is non-toxic / safe / not a harmful product
- the process uses nitrogen(I) oxide which is used up, rather than being released into the atmosphere from the other process (and causing global warming)
- the process is exothermic and the heat produced can be used elsewhere
- a relatively moderate operating temperature reduces overall costs
- high atom economy

Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning QWC [1]

Total [14]

Q.10 (a) K $\rightarrow$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (1)

There is one outer electron and the loss of this electron gives a stable potassium ion with a full outer shell/ ion more stable than the atom (1) [2]

(b) (i) $\Delta T = 4.8\ ^oC$ (1)

$$\Delta H = -\frac{250 \times 4.2 \times 4.8}{0.125} = -40320\ J\ mol^{-1}\ /\ -40.3\ kJ\ mol^{-1}$$ (2) [3]

✓ for negative sign
✓ correct value with relevant units

(ii) e.g. The volume used was not precise in measurement as the readings on a beaker are only approximate (1)

The experiment was performed in a beaker and this was not insulated and heat was lost to the surroundings (1) [2]

there may be other acceptable answers here, for example based on slow dissolving

(c) (i) 0.050 [1]

(ii) (0.050 × 24.0) = 1.20 (dm^3) [1]

(iii) $\% \ v/v = \frac{1.20 \times 0.001 \times 100}{2}$ (1) = 0.06 (1) [2]

(d) An increase in the concentration of (aqueous) carbon dioxide causes the position of equilibrium to move to the right. (1)

This causes calcium carbonate to become aqueous calcium (and hydrogencarbonate) ions / dissolve (1)

weakening shells / causing difficulty in formation of shells (1) [3]

Organisation of information clearly and coherently; using specialist vocabulary where appropriate QWC [1]

Total [15]

Q.11 (a) (i) I burette / (graduated) pipette [1]

II volumetric / graduated / standard flask [1]

(ii) 0.0064 [1]

(iii) 1.20 g / 100 cm^3 solution [1]

(iv) 12.0 g / 100 cm^3 solution [1]

(b) (i) The catalyst is in a different physical state to the reactants. [1]

(ii) Bonds broken

2 H-H	$\rightarrow$ 872	1 C-O	$\rightarrow$ 360
1 C-H	$\rightarrow$ 412	1 O-H	$\rightarrow$ 463
1 C=O	$\rightarrow$ 743		

Total +2850 kJ (1)

Bonds made

3 C-H	$\rightarrow$ 1236
1 C-O	$\rightarrow$ 360
3 O-H	$\rightarrow$ 1389

Total -2985 kJ (1)

$\Delta H = 2850 - 2985 = -135 \text{ kJ mol}^{-1}$ (1) [3]

(c) Relative molecular mass is a relative quantity (based on $^{1}/_{12}$th of the ^{12}C atom as one unit). [1]

(d) (i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]

(ii) C_2H_4O [1]

Total [12]

Total Section B [70]

GCE CHEMISTRY - CH2

JANUARY 2013 MARK SCHEME

SECTION A

Q.1	Calcium – Bones, teeth, muscle contraction. Magnesium – chlorophyll, activation of ATP. (Both for 1 mark)			[1]
Q.2	4,4-dimethylpentan-1-ol (1)			[1]
Q.3	(a)	Ability of atom to attract electrons <u>in a</u> covalent <u>bond</u> towards itself.		[1]
	(b)	δ- F-Cl δ+ δ+ At-Cl δ- Both needed for mark		[1]
Q.4	CH_2 (Accept H_2C)			[1]
Q.5	(a)	C		[1]
	(b)	B		[1]
Q.6	Both O_2 and O_3 have oxidation states of zero (1) No change in oxidation state (1)			[2]
Q.7	Reversible change in properties when conditions change.			[1]

Total Section A [10]

SECTION B

Q.8	(a)	(i)	$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ (state symbols not required)	[1]
		(ii)	white precipitate	[1]
	(b)	(i)	apple-green / yellow-green (no credit for 'green')	[1]
		(ii)	Reagents – silver nitrate (1) Observation – white precipitate (1) Must have correct reagent to get observation	[2]
	(c)		Mass produced by cooling 1 dm^3 = 358-312 = 46 g (1) Mass produced by 200 cm^3 = 46 x 200 ÷1000 = 9.2 g (1)	[2]
	(d)		M_r of anhydrous $BaCl_2$ = 208 (1) Water content = 36 so *x* =2 (1)	[2]
	(e)	(i)	$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$	[1]
		(ii)	I. Moles = 50 x 0.50 ÷ 1000 (1) = 0.025 moles (1)	[2]
			II. Filtration	[1]
			III. Moles $BaCl_2$ = moles HCl ÷ 2 = 0.0125 mol (1)	
			Mass hydrated $BaCl_2$ = 0.0125 x 244 = 3.05 g (1)	[2]

Total [15]

Q.9 (a) (i) ultraviolet / sunlight [1]

(ii) A species with an unpaired electron. [1]

(b) $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$ (1)
$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$ (1) [2]

(c) (i) Two $CH_3\bullet$ radicals combine (in a termination reaction). [1]

(ii) 24.3 ÷ 12 = 2.025 for C   4.1 ÷ 1.01 = 4.059 H   71.6 ÷ 35.5 = 2.017 Cl (1)
CH_2Cl (1) [2]

(d) (i) Nucleophilic substitution [1]

(ii) Methanol has hydrogen bonding between molecules (1)
Chloromethane has van der Waals forces / dipole-dipole forces between molecules (1)
Hydrogen bonding is stronger than Van der Waals/dipole-dipole (1) [3]

(iii) Acidified potassium dichromate / acidified potassium manganate(VII) (1)
Heat /warm (1)   (Need correct reagent to gain heat mark) [2]

(e) Compounds **B** and **C** are stable enough to reach the ozone layer OR Compound **D** would not reach the ozone layer as it would decompose in the lower atmosphere. (1)

(The C-Cl forms) Cl• which will decompose the ozone. (1)

Compound **A** does not contain chlorine, (so it cannot form Cl•) / Compound A has a lower RODP (1)

[3]

Total [16]

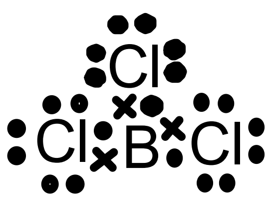
Q.10 (a)

- BCl_3 is trigonal planar or clear diagram.
- NCl_3 is pyramidal or clear diagram.
- BCl_3 has 3 bonded pairs
- NCl_3 has 3 bonded pairs
- NCl_3 has a lone pair
- BCl_3 has no lone pair
- Electron pairs repel to be as far from each other as possible / position of minimum repulsion.
- Lone pairs repel more than bonded pairs.

First two points and any other 4 for (1) each up to 6 max [6]

- *QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter.[1]*
-
- *QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning.[1]* [2]

(b)



accept crosses and dots exchanged (1)

Electron deficient: outer shell of boron has less than 8 electrons / is not full.(1) [2]

(c) NH_3 can form hydrogen bonds with water molecules (so it dissolves) (1)
NCl_3 cannot form hydrogen bonding. (1) [2]

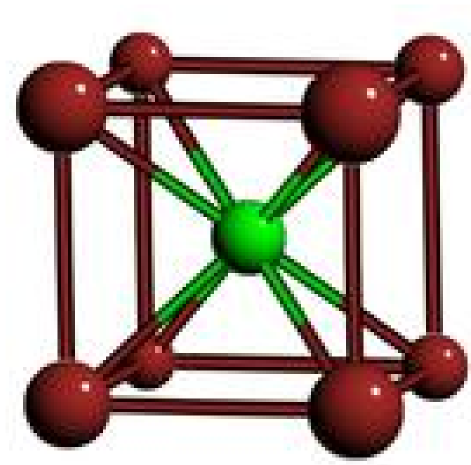
(d)

- Covalent has a pair of shared electrons one from each atom (1)
- Coordinate has a pair of shared electrons both electrons from same atom (1)

[2]

Total [14]

Q.11 (a) (i)



Clear 8 coordination number (1)
Labels of both Cl^- and Cs^+ (either way round) (1) [2]

(ii) Cs^+ ion larger than Na^+ so can have a larger coordination number. [1]

(b) (i) Any three from the following for (1) each up to 3 max – can gain these from labelled diagram

- Layers of carbon atoms.
- Hexagons of carbon atoms / each carbon bonded to three others.
- Weak forces between layers.
- Delocalised electrons above and below plane. [3]

QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate. [1]

(ii) Delocalised electrons in graphite can move to carry a current (1)
Diamond has no delocalised electrons (1) [2]

(iii) Van der Waals forces between molecules need to be broken to form iodine gas (1)

Covalent bonds need to be broken to form a gas from diamond/graphite (1)

Van der Waals forces are much weaker than covalent bonds (1)
[3]

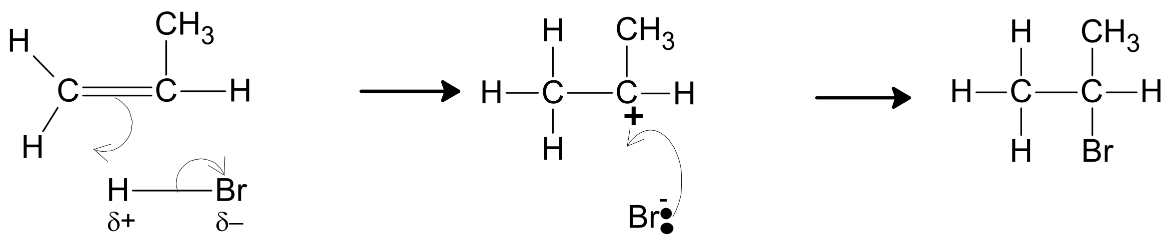
Total [12]

Q.12 (a) (i) Molecules with different numbers of carbon atoms have different boiling points. [1]

(ii) Any suitable reaction, e.g. $C_{10}H_{22} \rightarrow C_4H_8 + C_6H_{14}$ [1]

(b) (i) Turns from orange to colourless (no credit for 'red') [1]

(ii) (1) for arrows in first diagram; (1) for arrow in second diagram; (1) for all charges.



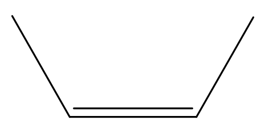
[3]

(iii) Ethanol OR Alcohol solution / Heat - both required [1]

(c) (i) Restricted rotation about double bond in but-2-ene but not butane (1)

2 groups attached to each carbon of the double bond are different in but-2-ene but in propene one carbon has the same two groups attached (1) [2]

(ii)



Accept any valid representation [1]

(d) (i) Steam, phosphoric acid catalyst, (1) 300°C, 70 atm pressure (1) [2]

(ii) Butan-2-ol will have IR absorptions at 2500-3550 cm^{-1} / 1000 – 1300 cm^{-1} and butene will not
OR
But-2-ene will have an IR absorption at 1620-1720 and butan-2-ol will not [1]

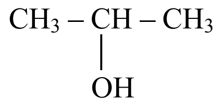
Total [13]

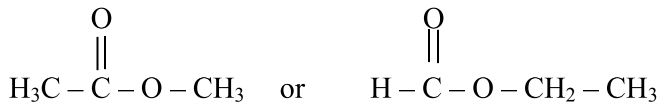
Total Section B [70]

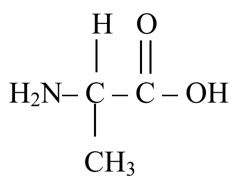
GCE CHEMISTRY - CH4

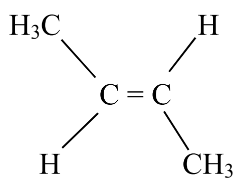
JANUARY 2013 MARK SCHEME

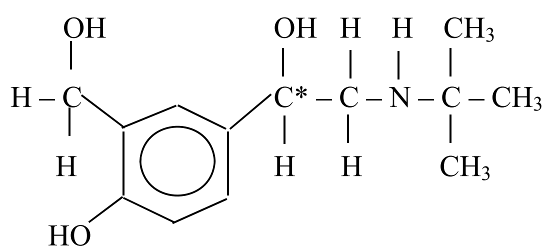
Section A

1. (a)(i)  [1]

(ii)  [1]

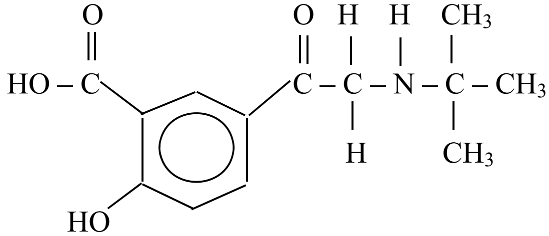
(iii)  [1]

(iv)  (or Z form) [1]

(b)(i)  [1]

(ii) The isomers rotate the plane of polarised light in opposite directions [1]

(iii) Side effects from other optical isomer / lower dose needed / improved pharmacological activity / only one isomer has correct orientation to bind with biological molecule [1]

(iv)  [2]

(1 mark for acid (accept aldehyde), 1 mark for ketone)

(c)(i) Ethylamine, ethanol, phenol, ethanoic acid [1]

(ii) Ethylamine is basic because it accepts a proton readily (1) due to the lone pair of electrons on the nitrogen. (1)
Phenol is acidic because it loses a proton / the anion formed is stabilised (1) by delocalisation of the negative charge over the benzene ring. (1)
(Accept description e.g. in phenoxide ion lone pairs of electrons on oxygen become delocalised with electrons in benzene ring.) [4]

Total [14]

2. (a)

	Butan-2-ol	Ethanal	Ethanol	Propanone
2,4-DNP	No reaction	Yellow-orange precipitate	No reaction	Yellow-orange precipitate
Tollens' reagent	No reaction	Silver mirror	No reaction	No reaction
I_2/NaOH	Yellow precipitate	Yellow precipitate	Yellow precipitate	Yellow precipitate

(1 mark for each column) [4]

(b)(i) Electrophilic addition [1]

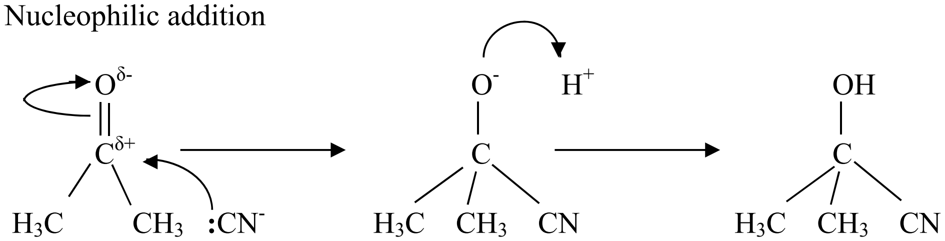
(ii) Carbonium ion / carbocation / electrophile [1]

(iii) Bromination / HBr addition / hydrogenation[1]

(iv) Secondary carbocation more stable than primary carbocation [1]

(c)(i) Nucleophilic addition [1]

(ii)



[3]

1 mark electron movement
1 mark charges

1 mark intermediate
and electron movement

(Accept $CN^{\delta-} – H^{\delta+}$ for CN^-)

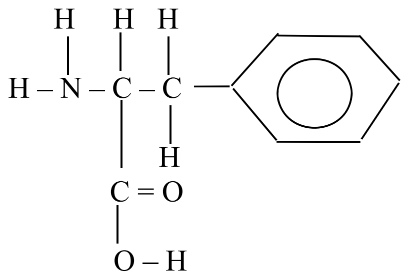
Total [12]

3. (a) Intermolecular bond formed (1) when hydrogen attached to a highly electronegative atom (1) is bonded to an electronegative atom attached to hydrogen (in another molecule) (1) forming a very strong dipole – dipole attraction (1) [3]

(maximum 3 marks)

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(b)



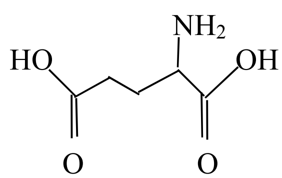
[1]

(c) Behaves as / can react with an acid or a base (1)

-COOH is an acidic group / donates proton, $-NH_2$ is a basic group / accepts proton (1)

[2]

(d)



[1]

(e) Moles MSG = 1/169.08 = 5.91×10^{-3} (1)

Concentration = 5.91×10^{-3}/ 0.1 = 5.91×10^{-2} (1) [2]

(f) (Neutral) $FeCl_3$ / Br_2 (1)

Purple colour / white precipitate (1) [2]

(g) 2,4-Dinitrophenylhydrazine / acidified sodium dichromate (1)

Yellow-orange precipitate / orange to green colour change (1) [2]

Total [14]

Total Section A [40]

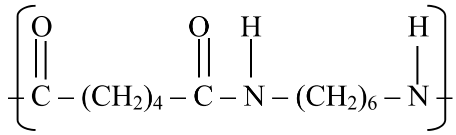
Section B

4. (a) For synthetic polymer:

Monomers: 1,6-Diaminohexane / ethane-1, 2-diol (1)

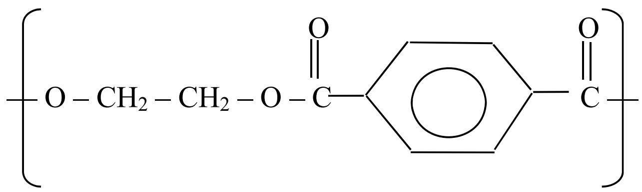
Hexanedioic acid / benzene-1,4-dioic acid (1)

Structure:



(1)

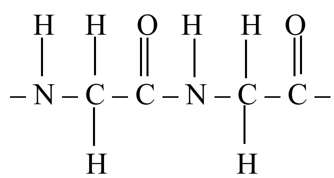
or



For natural polymer:

Monomers: aminoethanoic acid / 2-aminopropanoic acid (1)

Structure: e.g.

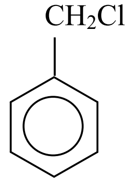


(1)

[5]

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

(b) (i)



[1]

(ii) 1,4-dichlorobenzene [1]

(iii) Chlorine (in the absence of ultraviolet light) (1)

$AlCl_3$ / $FeCl_3$ (as a halogen carrier) (1) [2]

(iv) Heat with NaOH (aq) (1)

add HNO_3(aq) followed by $AgNO_3$(aq) (1)

F gives white precipitate, **G** does not (1)

In **F**, the C–Cl bond is polarised / contains $C^{\delta+}$ or undergoes nucleophilic substitution (1)

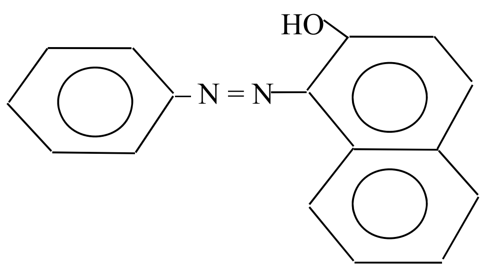
In **G** due to delocalisation of the π electron cloud of the ring with the p-orbital electrons of the chlorine (1)

the C–Cl bond is too strong to break/ does not undergo nucleophilic substitution (1) [6]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(c)(i) To prevent decomposition of benzenediazonium chloride / HNO_2 [1]

(ii)



[1]

(iii) A chromophore is the group of atoms responsible for the colour of the compound (by causing absorption in the visible region of the spectrum) [1]

Total [20]

5. (a)(i) Moles HCl = 5.4×10^{-3} (1)

M_r **B** = $\frac{0.395}{0.0054}$ = 73.1 (1) [2]

(ii) **B** is basic therefore must be amine (1)

C reacts with Na_2CO_3 therefore must be an acid (1)

D is oxidised to **C** therefore must be an alcohol (1)

A hydrolyses to acid but does not contain oxygen therefore must be nitrile (1)

B is $CH_3CH_2CH_2CH_2NH_2$ (1)

C is $CH_3CH_2CH_2COOH$ (1)

D is $CH_3CH_2CH_2CH_2OH$ (1)

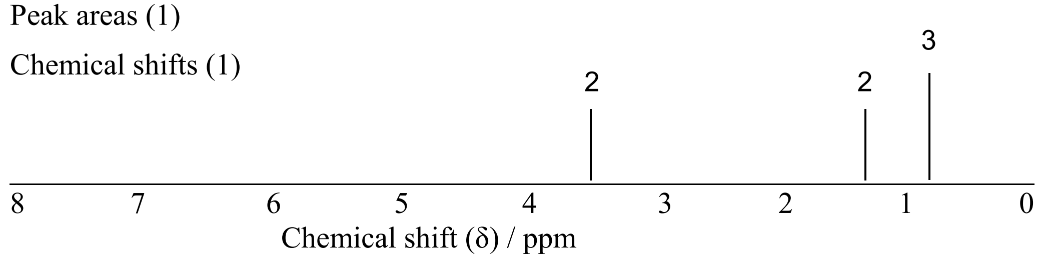
A is $CH_3CH_2CH_2CN$ (1) [8]

(4 marks structures – if 3 carbons in chains penalise only once
4 marks reasons – accept alternative reasons)

(b) $CH_3CH_2CH_2Cl$

Peak areas (1)

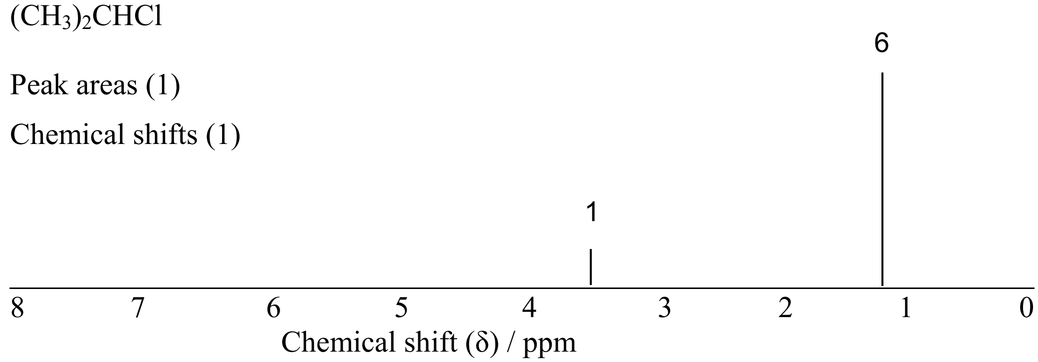
Chemical shifts (1)



$(CH_3)_2CHCl$

Peak areas (1)

Chemical shifts (1)



[4]

(c)(i) 2 steps instead of 3 / CH_3COCH_3 can be sold / reagents are cheaper / gives a higher yield / easier to extract phenol / phenol formed more quickly / fewer reactants [2]
(Accept any 2)

(ii) Lower temperature required / catalyst costs less / catalyst less likely to break up / catalyst less toxic or safer [1]

(d) Moles phenol = 58.75/94.06 = 0.625 (1)

Maximum mass aspirin = 0.625 × 180.08 = 112.55 g (1)

65% yield, therefore mass aspirin = 73.16 g (1) [3]

Total [20]

Total Section B [40]

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