GCE MARKING SCHEME

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2012 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

SECTION A

Q.1

1s	2s	2p			3s	3p		
↓↑	↓↑	↓↑	↓↑	↓↑	↓↑	↓↑	↑	↑

[1]

Q.2 B / 13 [1]

Q.3 Acid: Proton donor (1)

Dynamic equilibrium: Reversible reaction where the **rate** of forward and reverse reactions is equal (1) [2]

Q.4 (a)

	1	2	3	4
Volume used / cm^3	20.75	20.20	20.10	20.30

[1]

(b) 20.20 cm^3 [1]

Q.5 A [1]

Q.6 (a) Ratio of C:H is 1:1.33 (1)
Emp. Formula = C_3H_4 (1) [2]

(b) Molecular formula = C_9H_{12} [1]

SECTION A TOTAL [10]

SECTION B

Q.7 (a) (i) Temperature: 298K / 25°C (1) Pressure: 1 atm / 101.325 kPa or 100 kPa (1) [2]

(ii) Hydrogen gas is an element in its standard state [1]

(iii) $\Delta H = \Delta H_f (C_5H_{12}) + 5\ \Delta H_f (H_2O) – 5\ \Delta H_f (CO) – 11\Delta H_f (H_2)$ (1)

$\Delta H_f (C_5H_{12}) = -1049 - 5 (-286) + 5 (-111)$ (1)

$\Delta H_f (C_5H_{12}) = -174$ kJ mol^{-1} (1) [3]

(b) (i) Catalyst in different state to reactants [1]

(ii) Catalysts provide an alternative route (1) with a lower activation energy (1) [2]

(iii) Lower temperature or less time so less energy needed / Can make alternative production method possible with sustainable starting materials or less waste products [1]

(iv) At higher temperatures particles have more energy (1)

More collisions have energy above activation energy (1)

(Can obtain these two marks from correctly labelled Boltzmann energy distribution plot with two temperature lines (1) and Activation energy (1))

Successful collisions occur more frequently (1) – 3 max [3]

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

(c) (i) No effect (1)

Same number of (gas) molecules on both sides of reaction (1) [2]

(ii) Lower yield of hydrogen (1)

Reaction shifts in endothermic direction to (try to counteract increase in temperature) (1) [2]

(iii) No effect [1]

Total [19]

Q.8 (a) Be: 800 - 1000 kJ mol^{-1} (1)

Ne: 1700 – 2300 cm^{-1} (1) [2]

(b) Be (g) → Be^+ (g) + e [1]

(c) (i) Greater nuclear charge on He (1)

No increase in shielding / Outer electrons same distance from nucleus / Outer electrons in same shell (1) [2]

(ii) Outer electron in O is paired in orbital / Outer electron for N is unpaired (1)

Repulsion between paired electrons makes it easier to remove outer electron of oxygen (1) [2]

(d) (i) Electrons excited to a higher energy level (1)

Energy levels are quantised (1)

Electrons drop from higher to lower energy levels (1)

Energy is emitted as light (1) – 3 max [3]

Lines represent the energy emitted (1) when an excited electron drops back (1) from one energy level to another (1)

QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(ii) Find frequency of convergence limit (1) for Lyman series (1)

Ionisation energy is given by E=hf / Energy $\propto$ frequency (1) [3]

Total [14]

Q.9 (a) M_r (PbS) = 239.1 M_r (PbO) = 223 (1)

Moles of PbS = 20,000 ÷ 239.1 = 83.65 moles (1)

Mass of PbO = 83.65 x 223 ÷1000 = 18.7 kg (1) [3]

(b) (i) Sulfur dioxide: Acid rain (1)

Carbon dioxide: Climate change / global warming / acidification of oceans (1) [2]

(ii) I. Sum of M_r of reactants = 223 + 28 = 251 (1)

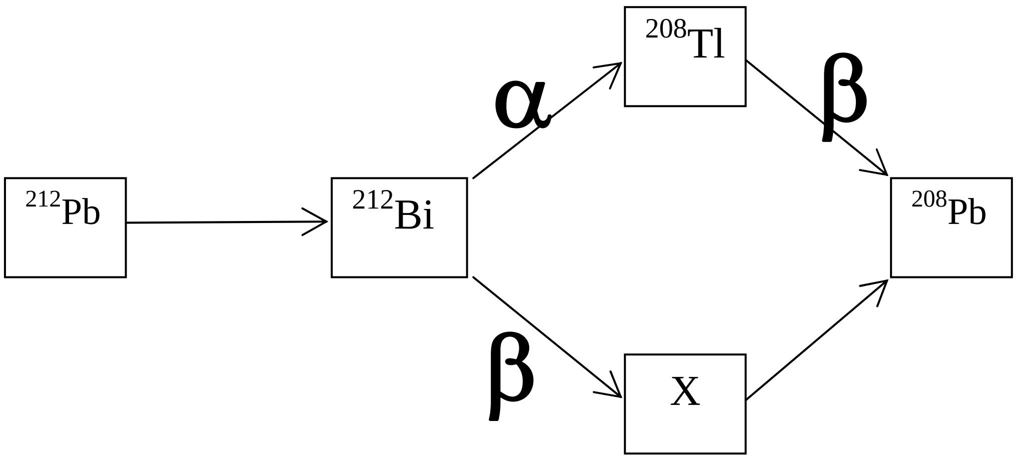
Atom economy = (207 ÷ 251) x 100 = 82.5% (1) [2]

(ii) II. Method 1 as higher atom economy means less waste / more useful product [1]

(c) (i) Symbol = Po (1) Mass number = 212 (1) [2]

(ii) All three arrows labelled correctly, as shows below, gives two marks

Any two arrows labelled correctly gives one mark [2]



(iii) γ-radiation is high energy / frequency electromagnetic waves (1)

It affects neither atomic number nor mass number / it changes neither the number of protons nor neutrons (1) [2]

(iv) 31.8 hours = 3 half lives (1)

Mass remaining after 3 half lives = 3mg (1) [2]

(d) A_r = [(206.0 x 25.48) + (207.0 x 22.12) + (208.0 x 52.40)] ÷ 100 (1)

A_r = 207.3 (1)

1 mark for correct significant figures (answer must be reasonable) [3]

Total [19]

Q.10 (a) (i) M_r ($CuSO_4.5H_2O$) = 249.7 [1]

(ii) I. Moles of copper(II) sulfate

= 0.250 x 250/1000 = 6.25 x 10^{-2} moles (1)

Mass = 6.25 x 10^{-2} x 249.7 = 15.6 g (1) [2]

II. 1 mark each for:

- Weighing method
- Dissolve copper sulfate in a smaller volume of distilled water
- Transfer to 250.0 cm^3 volumetric / standard flask
- Use of funnel
- Wash funnel / glass rod / beaker with distilled water into volumetric flask
- Add distilled water up to mark
- Shake solution / mix thoroughly 5 max [5]

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

(b) (i) Powder has a greater surface area (1) so gives a higher rate of reaction (1) [2]

(ii) Extrapolate lines from start (level at 21.3°C) and end (through points at 180-270 seconds) (1)

Temperature rise = 6.0°C (Range 5.8-6.2°C) (1) [2]

(iii) I. Moles = 0.250 x 0.05 = 1.25 x 10^{-2} moles [1]

II. Zinc is the limiting reagent / Copper(II) sulfate is in excess [1]

III. ΔH = -(50)x 4.18 x 6.0 ÷ (6.12 x 10^{-3}) (1)

ΔH = -204902 J mol^{-1}

ΔH = -205 kJ mol^{-1} (1) [2]

IV. Enthalpy measures chemical energy, and as heat energy increases, chemical energy must decrease [1]

Total [18]

SECTION B TOTAL [70]

GCE Chemistry – CH2

SECTION A

Q.1 They show a change in properties with a change in conditions (1)

This change in properties is reversible (1) [2]

Q.2 Equation $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (1)

pH Accept any value 8 to 14 inclusive / above 7 (1) [2]

Q.3 4-methylpent-2-ene [1]

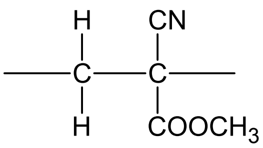
Q.4 (a) Orange to green [1]

(b) (i) C─H [1]

(ii) C [1]

(iii) 1650 to 1750 cm^{-1} C = O [1]

Q.5

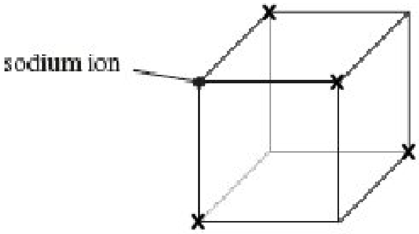


[1]

SECTION A TOTAL [10]

SECTION B

Q.6 (a) (i) [1]



Any of crosses shown

(ii) 6 (not 6,6) [1]

(b) Stir the mixture (before filtering) / heat (1)
Wash the mudstone / residue in the filter paper with water (and add the washings to the filtrate) (1) [2]

(c) (i) Add $AgNO_3$ / Ag^+ ions (assume aqueous) (1) [2]
White precipitate (1)

(ii) Add (aqueous) sodium hydroxide (solution) (1) gives (faint) white precipitate with kainite, no reaction with rock salt (1)

OR

Add barium chloride / barium nitrate / barium ions (1) gives white precipitate with kainite, no reaction with rock salt (1)

OR

Add potassium carbonate / carbonate ions (1) gives white precipitate with kainite, no reaction with rock salt (1) [2]

(d) (i) (The gaining of an electron) gives a full / stable (outer) electron shell [1]

(ii) There is less attraction between the nucleus and the (incoming) electron / oxidising power decreases down the group (increases in size is a neutral answer) [1]

(e) (i) The C–Cl bond (present in 1,1,1-trichloroethane) is **weaker** than the C–H bond (in methylcyclohexane) (1) and is broken by UV light / radicals present (that damage the ozone layer) (1) [2]

(ii) Reagent(s) Bromine (aqueous) (1)
Observation red/ brown $\rightarrow$ colourless / decolourised (1) [2]

Total [14]

Q.7 (a) (i) % of solid remaining $= \frac{2.01 \times 100}{3.24} = 62.0$ (1)

% decomposition = 87 (1) [2]

(ii) I To avoid contamination / ensure that all Ca^{2+} ions came from the solid [1]

II So that all the calcium hydroxide that could dissolve had dissolved / to produce a saturated solution / to ensure homogeneity [1]

(iii) I 0.0225 [1]

II 0.0225 x 74.1 = 1.67 (g dm^{-3}) [1]

(iv) Calcium carbonate was removed (by filtration) [1]

(b) Brick red (1)
The 'calcium' will give a flame test colour (1) [2]

(c) $Ca^{2+} + SO_4^{2-} \rightarrow CaSO_4$ [1]

(d) Find out if the nano-particles have 'side effects' / further research to see if they work [1]

(e) 5000 tonnes of fluorapatite give 8600 tonnes of superphosphate (1)

but yield is 93% $\therefore \frac{8600 \times 93}{100}$ = 7998 / 8000 (tonnes) (1) [2]

(f) The two elements both have 2 electrons in their outer energy level / valence shell can both lose 2 electrons to become Ra^{2+} / Ca^{2+} / OWTTE [1]

Total [14]

Q.8 (a) (i) (+) 7 [1]

(ii) M_r H_2O_2 is 34.02 / 34 (1)

Concentration $= \frac{76.5 \times 10}{34.02}$ = 22.49 / 22.5 (mol dm^{-3}) (1) [2]

(iii) A covalent bond where the electrons are not shared equally between the atoms / unequal electron density (1) because of differences in electronegativity between the nitrogen and hydrogen atoms (1) [2]

(iv) A (covalent) bond where **both** electrons come from the same / one atom [1]

(v) (Nitrogen has three bonding pairs and one lone pair of electrons) and these repel each other to take up the position of minimum repulsion (1) The lone pair / bonding pair repulsion $>$ bonding pair / bonding pair repulsion (1) [2]

(b) (i) It contains an unpaired electron [1]

(ii) I $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$ [1]

II A radical reacts to produce a new radical (that can continue the process) [1]

(iii) C_7H_{16} [1]

(iv) (Bond fission where a covalent bond breaks) and each atom receives an electron [1]

Total [13]

Q.9 (a) Hydrogen bonding occurs between (1) oxygen, nitrogen or fluorine (1) of one molecule and hydrogen, which is bonded to oxygen / nitrogen / fluorine of another molecule (1)
Alkanes do not contain an O-H, N-H or F-H bond and cannot therefore hydrogen bond to water molecules (1) [4]

QWC Candidates should have use 'a selection and form of writing appropriate to purpose and to complexity of subject matter' [1]

(b) (i) The (purified) petroleum is separated by heating (1) due to the different boiling temperatures of different fractions (1)

OR the mixture is vaporised (1) and then condensed according to boiling temperatures (1) (as at the oil refinery) [2]

(ii) $CuCl_2$ Cu +2 CuCl Cu +1 (1)

(reduction occurs when) the oxidation number becomes less positive (1) [2]

(c) (i) Same molecular formula but a different structural formula / structure [1]

(ii) Both of the carbon atoms of the double bond have different atoms / groups bonded to them (1)
There is no free rotation about the double bond (1) [2]

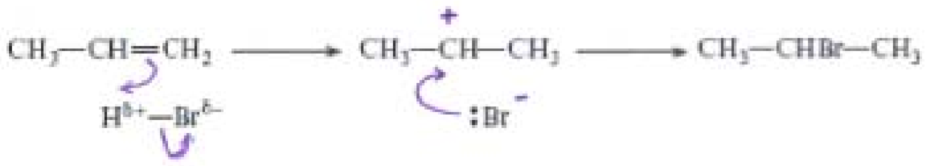
(iii) M_r of compound **A** is 146.3 / 146 (1)

Cost per mole is $\frac{146.3 \times 48 \times 100}{100 \times 73}$ = £96.20 (1)

(Accept £96.00 per mole if M_r of 146 has been used) [2]

Total [14]

Q.10 (a) (i)



curly arrows (1)
charges (1) [2]

(ii) Nucleophile hydroxide ion / OH^- / water (1)

Substitution the replacement of one functional group by another (1) [2]

(iii)

CH_3CH_2Br + NaOH → CH_2 CH_2 + **NaBr** + **H_2O**

(accept **Na^+** and **Br^-** in place of NaBr) [1]

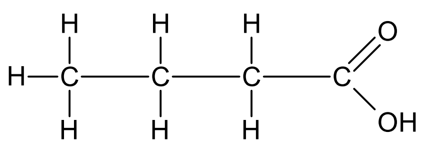
(b) M_r = 88 (1)

'M_r' R = 88 - (45) = 43 (1)

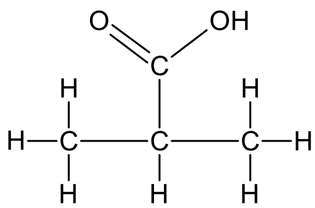
(45) ← COOH

∴ R (an alkyl group) is C_3H_7

thus acid is



or



(1) [3]

(c) In graphite each carbon atom is bonded to three other carbon atoms (1) (using covalent bonding)
The other (outer) electron for each carbon atom is delocalised (1), throughout the structure and is able to move (1), conducting electricity
In iodine the two iodine atoms are bonded together (using covalent bonding) and there are no free electrons to carry the charge (1)
Mention of covalent bonding for either element (1) [5]

QWC Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning (1)
Organisation of information clearly and coherently; use of specialist vocabulary where appropriate (1) [2]

Total [15]

SECTION B TOTAL [70]

GCE Chemistry – CH4

SECTION A

Q.1 (a) (i) **A** [1]

(ii) **D** [1]

(iii) **C** [1]

(iv) **C** [1]

(b) (i) Nucleophilic substitution [1]

(ii) The C–Cl bond in chlorobenzene is stronger than in 1-chlorobutane (1) due to delocalization of electron density from the ring with the bond (1)

OR

Delocalised electrons in chlorobenzene (1)
repel lone pair of electrons on nucleophile / ammonia (1)

[2]

(iii) $C_4H_9NH_2 + CH_3COCl \longrightarrow C_4H_9NHCOCH_3 + HCl$ [1]

(iv) I Tin and **concentrated** hydrochloric acid (1)

Add sodium hydroxide (after cooling) (1)

Steam distillation to separate the product (1) [3]

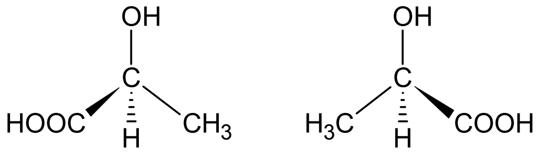
II $C_6H_5NN^+Cl^-$ [1]

III Azo dye / azo compound [1]

Total [13]

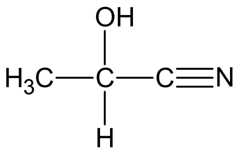
Q.2 (a) (i) A compound that can rotate the plane of polarised light. [1]

(ii)



[1]

(iii)



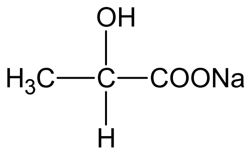
[1]

(iv) Reflux / heat with H_2O/H^+ [1]

(v) It contains an equal amount of the two enantiomers /
it is a racemic mixture (1)

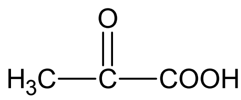
The rotating effect of one form exactly cancels out the effect of the other (1) [2]

(b) (i)



[1]

(ii)



[1]

(c) (i) 2-aminopropanoic acid [1]

(ii) Nitrous acid / nitric(III) acid / HNO_2 [1]

(iii) It exists as a zwitterion (1)

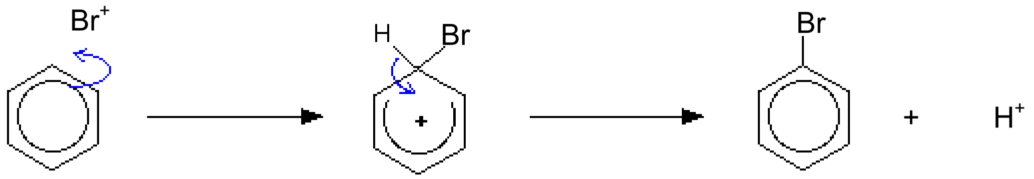
strong electrostatic attractions / ionic bonds between different zwitterions (1) [2]

Total [12]

Q.3 (a) (i) Electrophilic substitution [1]

(ii)

$Br_2 + FeBr_3 \longrightarrow Br^+ + FeBr_4^-$



Formation of Br^+ (1), curly arrows (1), intermediate (1) [3]

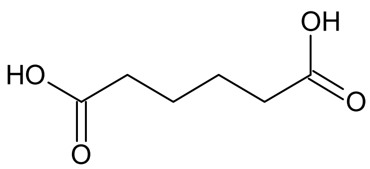
(b) (i) The extra stability in the benzene molecule due to electron delocalisation / the difference in energy between the experimental ΔH^θ reaction for benzene and the ΔH^θ reaction according to the Kekulé structure [1]

(ii) If benzene had 3 double bonds enthalpy change would be
3 x –120 = –360 kJ mol^{-1} (1)

Delocalisation energy is difference between
–360 and –208 = 152 kJ mol^{-1} (1) [2]

(c) Benzene is carcinogenic / toxic [1]

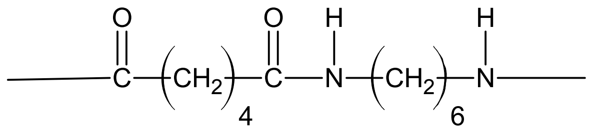
(d) (i) [1]



(ii) Reduction [1]

(iii) 1, 6-diaminohexane [1]

(iv) [1]



(v) Polyamide [1]

(vi) 226 tonnes nylon require 156 tonnes benzene (1)

800 tonnes nylon require 800 x $\frac{156}{226}$ = 552 tonnes (1) [2]

Total [15]

SECTION A TOTAL [40]

SECTION B

Q.4 (a) (i) Moles NaOH = 5.675×10^{-3} (1)

M_r **O** = $\frac{0.50}{0.005675}$ = 88.1 (1) [2]

(ii) **K** contains C=O due to 2, 4-dinitrophenylhydrazine reaction (1)

Contains CH_3CO due to positive iodoform test (1)

From M_r **K** must be CH_3COCH_3 (1)

O contains COOH due to neutralisation / decarboxylation reaction (1)

From M_r **O** must be $CH_3CH_2CH_2COOH$ / $(CH_3)_2CHCOOH$ (1) [5]

(iii) **L** is $CH_3CH(OH)CH_3$ (1)

M is C_3H_6 (1)

N is C_3H_8 (1) [3]

(iv) Concentrated H_2SO_4 / Al_2O_3 / concentrated H_3PO_4 [1]

(b) (i) To form the acid from the salt / to precipitate the acid / the salt is water soluble [1]

(ii) The acid is soluble in hot water but insoluble in cold water [1]

(iii) Moles = 3.2/40 = 0.08 (1)

Concentration = 0.08/0.04 = 2 mol dm^{-3} (1) [2]

(iv) Mass = 2.90 x 1.06 = 3.074 g (1)

Moles = 3.074/150.1 = 0.0205 (1) [2]

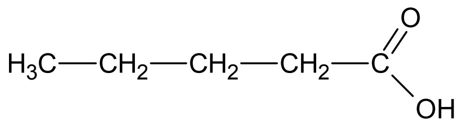
(v) Maximum mass = 0.0205 x 122 = 2.50 g (1)

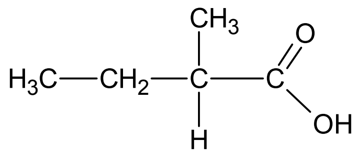
% yield = 1.45/2.50 = 58.0% (1) [2]

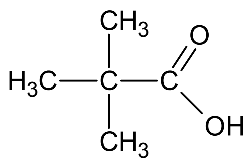
(vi) Hydrolysis not complete / equilibrium forms / C_6H_5COOH slightly soluble in water / two stages so some loss at both / mass lost during recrystallisation [1]

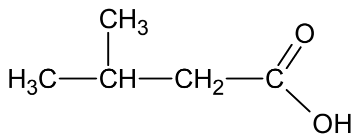
Total [20]

Q.5 (a)

P is  (1)

Q is  (1)

R is  (1)

S is  (1)

[4]

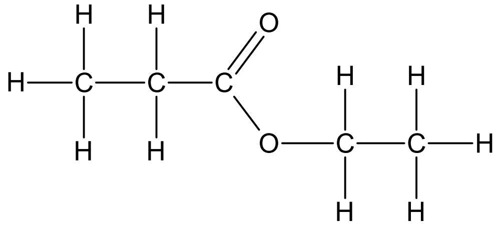
(b) (i) **T** neutral and sweet-smelling therefore an ester (1)

Infrared spectrum at 1750 cm^{-1} shows C=O and at 3000 cm^{-1} shows O–H therefore **X** is an acid (1)

Y is an alcohol, formed from ethanal must be ethanol (1)

5 carbons in ester therefore **X** must be propanoic acid (1)

Structure of **T** is



(1)

(Maximum 4 marks) [4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning (1)

Selection of a form and style of writing appropriate to purpose and to complexity of subject matter (1) [2]

(ii) I Reagent to form **Y** is $NaBH_4$ / $LiAlH_4$ [1]

II Sulfuric acid acts as a catalyst / removes water so pushes equilibrium to right [1]

(c) $CH_3(CH_2)$ 0.1 to 2.0 ppm triplet (1)

$(CH_3)CH_2O$ 3.5 to 4.0 ppm quadruplet (1)

CH_2CO 2.5 to 3.0 ppm singlet (1)

CH_3CO 2.0 to 2.5 ppm singlet (1) [4]

(d) Isomer **P** (1)

Only **P** can form hydrogen bonds between molecules (1)

Hydrogen bonds are the strongest intermolecular bonds / need more energy to break hydrogen bonds (1) [3]

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

Total [20]

SECTION B TOTAL [40]

WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk