GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

JANUARY 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2014 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.

Section A

Q.1		**D**		[1]
Q.2		**A**		[1]
Q.3	(a)	An electron formed when a neutron changes into a proton / an electron emitted by the nucleus		[1]
	(b)	^{32}S		[1]
	(c)	Time taken for half of the atoms in a radioisotope to decay (or similar)		[1]
	(d)	42 days		[1]
Q.4		Combustion of C and H_2 = (2 × –394) + (3 × –286) = –1646 kJ mol^{-1}	(1)	
		ΔH = –1646 – (–1560) = –86 kJ mol^{-1}	(1)	[2]

Q.5

	Ag	S		
Mass	1.08	0.16		
A_r	108	32		
Moles	0.01	0.005	(1)	
	2	1		
Formula = Ag_2S			(1)	[2]

Total Section A [10]

Section B

Q.6 (a) (i) **B** is $^{37}Cl^{+}$ (1)
C is $(^{35}Cl — ^{35}Cl)^{+}$ (1) [2]

(ii) **C** = 54, **E** = 6 (1)
Ratio of **C**:**E** is 9:1 (1) [2]

(iii) Ratio of ^{35}Cl:^{37}Cl is 3:1 (1)
Ratio of $^{35}Cl — ^{35}Cl$: $^{37}Cl — ^{37}Cl$ is 3:1 × 3:1 = 9:1 (1)

or

Probability of atom being
^{35}Cl is ¾ and that of ^{37}Cl is ¼ (1)

Probability of
$^{35}Cl — ^{35}Cl$ is ¾ × ¾ = 9/16
and $^{37}Cl — ^{37}Cl$ is ¼ × ¼ = 1/16 (1) [2]

(b) $A_r = \dfrac{(79 \times 50.69) + (81 \times 49.31)}{100}$ (1)

$A_r = 79.99$ (1) [2]

Total [8]

Q.7	(a)		Use weighing scales to weigh the metal oxide	(1)	
			Use measuring cylinder to pour hydrogen peroxide solution and water into a conical flask	(1)	
			Immerse flask in water bath at 35 ˚C	(1)	
			Add oxide to flask and connect flask to gas syringe	(1)	
			Measure volume of oxygen every minute for 10 minutes / at regular time intervals	(1)	
			(any 4 of above, credit possible from labelled diagram)		[4]
	(b)		Oxide **A** because reaction is faster		[1]
	(c)	(i)	18 cm^3		[1]
		(ii)	10 cm^3		[1]
	(d)		Concentration of hydrogen peroxide has decreased	(1)	
			reaction rate decreases / fewer successful collisions	(1)	[2]
	(e)		All the hydrogen peroxide has decomposed / the same quantity of hydrogen peroxide was used		[1]
	(f)		25 cm^3		[1]
	(g)		Reaction will take less time	(1)	
			Reactants collide with more (kinetic) energy	(1)	
			More molecules have the required activation energy	(1)	[3]
			QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter		[1]

Total [15]

Q.8 (a) Electrons within atoms occupy fixed energy levels or shells of increasing energy / nitrogen has electrons in two shells (1)
$1s^2\ 2s^2\ 2p^3$ (1)

Electrons occupy atomic orbitals within these shells / The first shell in nitrogen has s orbitals and the second shell s and p orbitals (1)

A maximum of two electrons can occupy any orbital / Each s orbital in nitrogen contains two electrons (1)

Each with opposite spins (1)

Orbitals of the same type are grouped together as a sub-shell / There are three p orbitals in nitrogen's p sub-shell (1)

Each orbital in a sub-shell will fill with one electron before pairing starts / In nitrogen's p sub-shell each orbital contains one electron (1)

(configuration mark + any 3 of above) [4]

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

(b) Atomic spectrum of hydrogen is a series of lines (1)
that get closer as their frequency increases (1)
(credit possible from labelled diagram)

Lines arise from atom / electrons being excited by absorbing energy (1)
electron jumping up to a higher energy level (1)
falling back down and emitting energy (in the form of electromagnetic radiation) (1)
to the n = 2 level (1)
(any **three** points for maximum 3 marks)

Since lines are discrete energy levels must have fixed values / Since energy emitted is equal to the difference between two energy levels, ΔE is a fixed quantity or quantum (1) [6]

(c) (i) It has greater nuclear charge (1)
but little / no extra shielding (1) [2]

(ii) In Be less shielding of outer electron (1)
outweighs smaller nuclear charge (1)

or

Be outer electron closer to nucleus (1)
Be has greater effective nuclear charge (1) [2]

(iii) I. Too much energy required to form B^{3+} ion [1]

II. $K^{+}(g) \rightarrow K^{2+}(g) + e^{-}$ [1]

III. Value of 1st and 3rd I.E. will be higher (1)
Value of 2nd I.E. will be smaller (1)
(accept large jump in I.E. value would be between 2nd and 3rd electrons for 1 mark) [2]

Total [19]

Q.9 (a) Enthalpy change when one mole of a compound is formed from its (constituent) elements (1)
in their standard states / under standard conditions (1) [2]

(b) (i) $H_2 + ½O_2 \rightarrow H_2O$ [1]

(ii) –242 = 436 + 248 – 2(O—H) (1)
2(O—H) = 926
O—H = 463 kJ mol^{-1} (1) [2]

(c) (i) I. Burning hydrogen will not produce CO_2 (or SO_2) as pollutants [1]

II. Hydrogen is very flammable, storing as MgH_2 is safer / MgH_2 is solid therefore volume occupied by given amount of hydrogen is less [1]

(ii) If the MgH_2 is not kept dry, hydrogen will be formed and there could be a potential explosion [1]

(iii) Moles $MgH_2 = \frac{70000}{26.32} = 2659.6$ (2660) (1)

Moles H_2 = 5319.2 (5320) (1)

Volume $H_2 = 1.28 \times 10^5\ dm^3$ (1) [3]

(d) (i) An increase in temperature would decrease the yield and an increase in pressure would increase the yield [1]

(ii) Forward reaction is exothermic so equilibrium shifts to the left as temperature is increased (1)

More gaseous moles on the l.h.s. so equilibrium shifts to the right as pressure is increased (1) [2]

(e) Lower temperatures can be used (1)
Energy costs saved (1)
More product can be made in a given time (so more can be sold) (1)
Enable reactions to take place that would be impossible otherwise (1)
Less fossil fuels burned to provide energy (so less CO_2 formed) (1)
(any 3 of above) [3]

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

Total [18]

Q.10	(a)		Moles NaCl = $\frac{900}{58.5} = 15.38$	(1)	
			Moles Na_2CO_3 = 7.69	(1)	
			Mass Na_2CO_3 = 7.69 × 106 = 815(.4) g	(1)	[3]
	(b)	(i)	2.52 g		[1]
		(ii)	Moles Na_2CO_3 = 0.02 Moles H_2O = 0.14 (1) x = 7	(1) (1)	[2]
	(c)	(i)	Moles = 0.5 × 0.018 = 0.009		[1]
		(ii)	0.0045		[1]
		(iii)	0.0045 × 106 = 0.477		[1]
		(iv)	% = 0.477/0.55 = 86.7 %		[1]

Total [10]

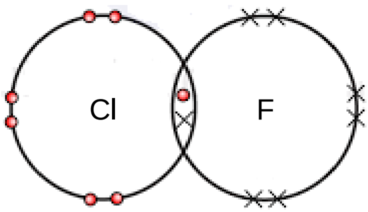
Total Section B [70]

Section A

Q.1 C [1]

Q.2 (a) $Cl^{\delta+}$— $F^{\delta-}$
Electronegativity decreases down the group / fluorine is more electronegative (than chlorine) / chlorine is less electronegative (than fluorine) [1]

(b) [1]



Q.3 It has a full / stable (outer) electron shell [1]

Q.4 (a) $C_6H_{12}Br_2$ [1]

(b) Elimination [1]

Q.5 Temperature 200-300 (accept 470-570K)

Pressure 60-70 (accept 6000-7000 kPa) [1]

Q.6 Hex-2-ene (ignore references to cis/trans/*E/Z*) [1]

Q.7 (a) A process of bond breaking where the two electrons (of the covalent bond) go to one of the two atoms in the bond [1]

(b) $(CH_3)_3C^+$ and Cl^- (accept $(CH_3)_3C^-$ and Cl^+) [1]

Total Section A [10]

Section B

Q.8 (a) In SO_2 the oxidation number of sulfur is +4

In SO_2F_2 the oxidation number of sulfur is +6 (1)

Increase in (positive) oxidation number is oxidation (1) [2]

(b) The electrons in the bonds between sulfur and fluorine and sulfur and oxygen take up the position of minimum repulsion / maximum separation [1]

(c) (i) A lone pair donor / a species that seeks out a relatively positive site [1]

(ii) eg H_2O / OH^- / Cl^- (or other halogen) / CN^- / correct formula of an amine [1]

(iii) A shift of **two** electrons [1]

(d) $SO_2F_2 + 2Ca(OH)_2 \rightarrow CaSO_4 + CaF_2 + 2H_2O$

[(1) for correct formulae, (1) for balancing **if** formulae correct] [2]

(e) (i) UV radiation (1) is able to break the C—Cl and C—Br bonds (1) giving radicals (1) that attack / breakdown the ozone layer [3]

(ii) The S—F bond in sulfuryl fluoride is too strong to be broken by UV radiation [1]

Total [12]

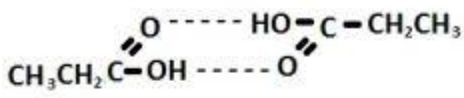
Q.9 (a) (i) 165 ± 5 °C [1]

(ii) As the number of carbon atoms in the acids increase the boiling temperature increases (1)
This is due to an increase in induced dipole-induced dipole / Van der Waals forces (1) between molecules (1) [3]

(iii) As the molecules increase in size the relative importance of the —COOH group decreases (1)
There is therefore less of a tendency to hydrogen bond **with water** (becoming less soluble) (1) [2]

(b) (i) Acidified (potassium) dichromate (accept H^+, $Cr_2O_7^{2-}$) / Acidified (potassium) manganate(VII) (accept H^+, MnO_4^-) [1]

(ii)



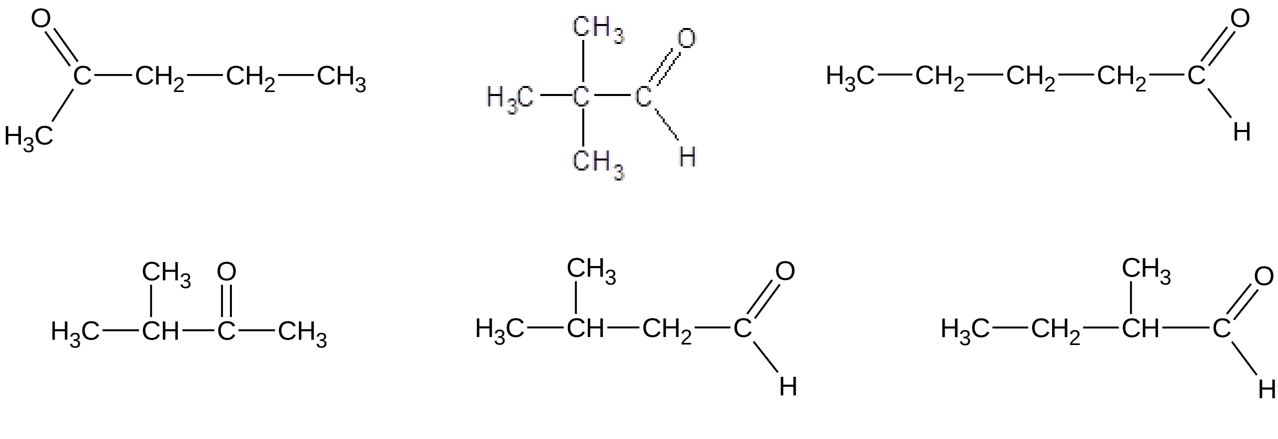
[1]

(iii) I 0.050 [1]

II 0.025 [1]

III 0.025 × 186 = 4.65 (g) [1]

(iv) Any 2 of the following:



[2]

(c) (i) $\frac{49.3}{12} = 4.11$ $\frac{43.8}{16} = 2.74$ (1) Ratio of C:O is 3:2 (1) [2]

(ii) There are four oxygen atoms per molecule ∴ 6 carbon atoms (and 4 oxygen atoms)

∴ n = 6 – 2 in the acid groups ∴ n = 4 [1]

Total [16]

Q.10 (a) (i) Number of moles of HCl $= \frac{80 \times 0.20}{1000} = 0.016$ (1)

Number of moles of calcium needed = 0.008 (1)

Number of moles of calcium actually used $= \frac{0.40}{40} = \sim 0.010$ (1)

($\therefore$ calcium is present in excess)

[Calculation could be carried out in grams] [3]

(ii) gas bubbles / effervescence / some calcium ‘dissolves’ / colourless solution produced [1]

(b) Mass of **E** in solution at 0 °C = 0.13 × 2 = 0.26 g (1)

$\therefore$ Quantity precipitated = 1.50 – 0.26 = 1.24 g (1) [2]

(c) (i) Brick red / orange-red [1]

(ii) Cream precipitate (accept off-white precipitate) [1]

(iii) $Ag^{+} + Br^{-} \rightarrow AgBr$ [1]

(iv) Red / brown solution [1]

(v) Calcium bromide is an ionic compound (1)
and contains Ca^{2+} and Br^{-} ions (1)
Chlorine reacts with the bromide ions in a redox / displacement reaction (1)
Chlorine is a more powerful oxidising agent / has a greater affinity for electrons than bromine (1)
$2Br^{-} + Cl_2 \rightarrow Br_2 + 2Cl^{-}$ (1) [5]

QWC: ensure that text is legible and that spelling, punctuation and grammar are accurate so that the meaning is clear [1]

Total [16]

Q.11 (a) Iodine contains weak van der Waals forces / bonds between each molecule (1)
Less energy is needed to overcome these weaker forces (1) *
Diamond contains strong covalent bonds between each atom (1)
and more energy is needed to overcome these 'bonds' (1) *
* alternative marks

Neither iodine nor diamond contain free / delocalised electrons to carry the charge (necessary for them to conduct electricity) (1) [4]

QWC: organise information clearly and coherently, using specialist vocabulary when appropriate [1]

(b) K^+ and I^- correctly given (1) and in their correct places on the diagram (1) [2]

(c) An excess / stoichiometric / 0.05 mol (1) of potassium sulfate (aq) is added to the barium chloride solution
Mixture is stirred (1) * and then filtered (1)
Precipitated barium sulfate is then washed with distilled water (1)
and dried (1) * [4]
* alternative marks

QWC: Select and use a form and style of writing appropriate to purpose and to complex subject matter [1]

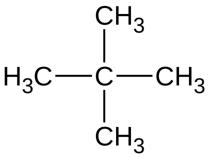
Total [12]

Q.12 (a) (i) Petroleum is heated/evaporated (1)
Fractions condense at different temperatures / separated into fractions with different boiling temperatures (1)

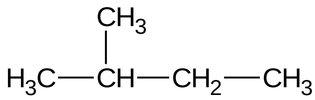
[2]

(ii) C_5H_{12} (1)

Branched chain therefore



or



(1)

[2]

(b) (i) It enables more useful compounds to be made from the compound [1]

(ii) $C_9H_{20} \rightarrow CH_4 + C_4H_6 + C_4H_{10}$ [1]

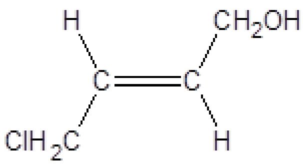
(c) (i) UV light [1]

(ii) A step during which a radical reacts and another one is formed [1]

(iii) $Cl\bullet + CH_4 \rightarrow \bullet CH_3 + HCl$

[or $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$] [1]

(d) (i)



[1]

(ii) Aqueous sodium hydroxide [1]

(iii) Pt / N / Pd [1]

(iv) Compound **E** does not contain an O—H bond (1)
This is present in Compound **D** at a frequency of 2500-3550 cm^{-1} (1)

[2]

Total [14]

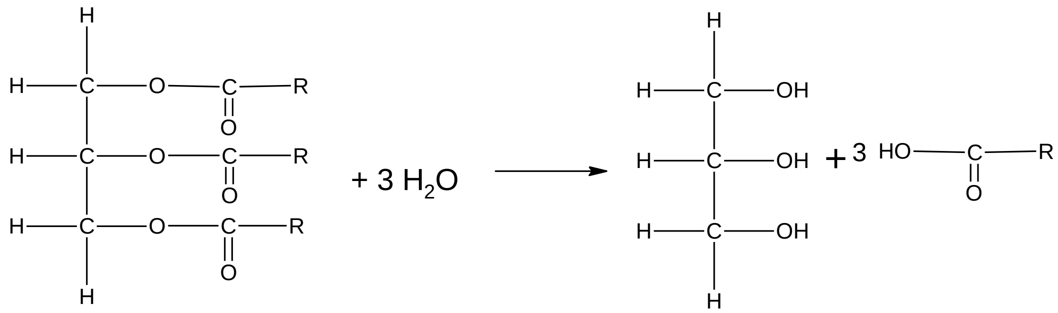
Total Section B [70]

CH4

Section A

Q.1 (a) Reagent(s): (aqueous) sodium hydroxide followed by acid (1)

Condition(s): Heat (to reflux) (1)



[IF NO ACID LISTED IN REAGENT, THEN EQUATION SHOULD CONTAIN SODIUM SALTS] (1) [3]

(b) (i) Reagent(s): (aqueous) bromine (1)
Observation(s): Changes from orange to colourless (1) [2]

(ii) Nickel / Platinum / Palladium [1]

(iii) Moles of hydrogen gas = $1.15 \div 24.0 = 4.79 \times 10^{-2}$ mol (1)
Moles of stearic acid produced = $4.79 \times 10^{-2} \div 2 = 2.40 \times 10^{-2}$ mol (1)
Mass of stearic acid = $2.40 \times 10^{-2} \times 284 = 6.80$ g (1) [3]

(c) (i) **C** $69.7 \div 12 = 5.808$ **H** $11.7 \div 1.01 = 11.584$ **O** $18.6 \div 16 = 1.163$ (1)
Empirical formula = $C_5H_{10}O$ (1) [2]

(ii) $C_{10}H_{20}O_2$ [1]

(d) e.g. biodiesel is renewable/won't run out / carbon neutral
do not accept 'produces less carbon dioxide' [1]

Total [13]

Q.2	(a)	Chromophore		[1]
	(b)	(i)	Melting temperature **lower** than literature value / melting occurs over a temperature range	[1]
		(ii)	Identify percentage or amount of impurities (1) Identify the number of compounds present or number of impurities (1)	[2]
	(c)	(i)	Acidified potassium dichromate (1) Heat and distil (1) do not accept 'reflux'	[2]
		(ii)	M_r of phenylmethanol = 108.08 M_r of benzenecarbaldehyde = 106.06 (1) 100% conversion would be 10.0 ÷ 108.08 × 106.06 = 9.815g (1) 86% yield = 9.815 × 86 ÷ 100 = 8.44g (1)	[3]
		(iii)	Two resonances in the range 5.8-7.0 ppm (1) These are doublets (1) One **singlet** at around 11.0 ppm (1) All resonances have the same area (1)	[4]

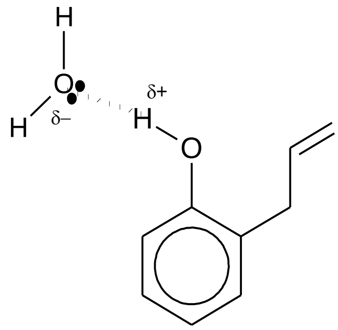
Total [13]

Q.3 (a) Isomers [1]

(b) (i) Peak at 2500-3550 cm^{-1} present in product but not reactant [1]

(ii) Add $FeCl_3$ (1)
Forms a purple solution (1) do not accept 'precipitate' [2]

(iii) 1 mark for correct location of hydrogen bond; 1 mark for dipole OR lone pair e.g.



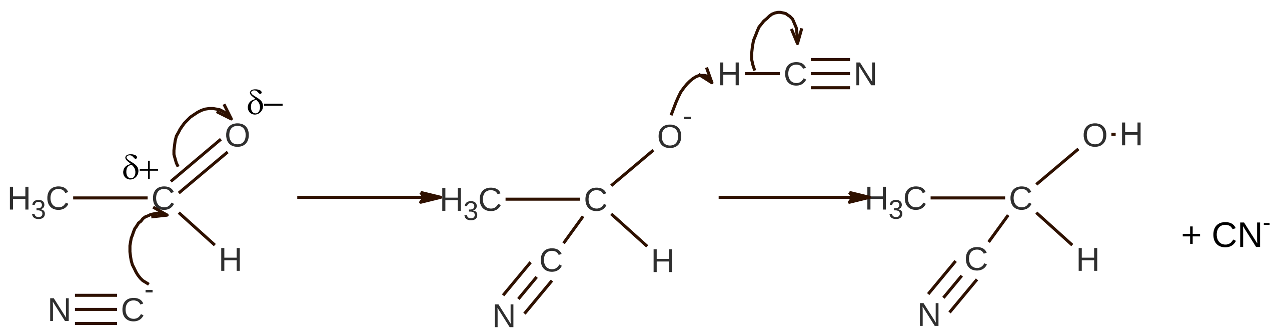
[2]

(c) Aromatic Claisen product is more acidic / better proton donor than product of 1,2-Wittig rearrangement (1)

The 1,2-Wittig rearrangement product is an alcohol, so the charge on the **anion** formed is localised / the **anion** is unstable (1)
The product of the aromatic Claisen rearrangement is a phenol, so the charge on the anion can be delocalised which stabilises it (1)
(Must be reference to 'anions'; (1) mark awarded for 'stability of anions' if no reference to delocalisation) [3]

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

(d) 1 mark for arrows in first stage; 1 mark for correct intermediate; 1 mark for arrow giving gain of proton in second stage (from HCN or from H^+); 1 mark for bond polarity – max 3 marks; lose 1 if incorrect final structure



Mechanism: Nucleophilic addition (1) [4]

Total [14]

Total Section A [40]

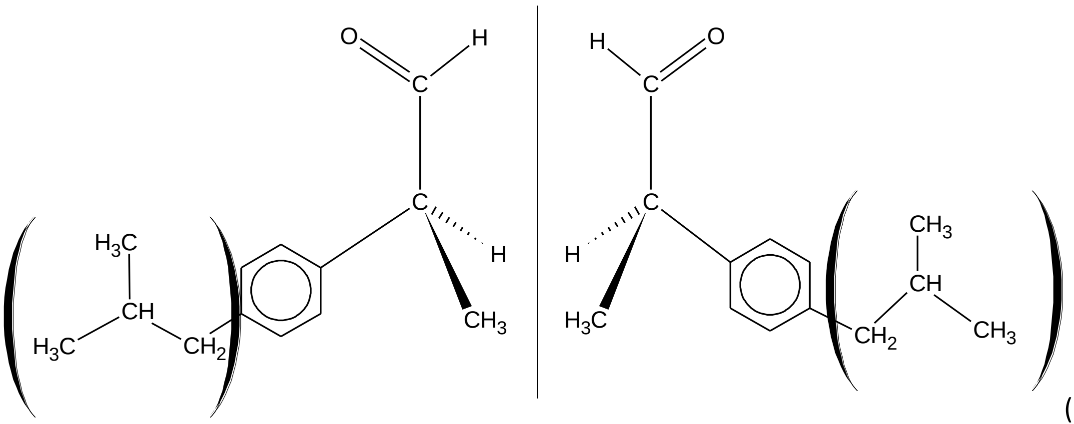
Q.4 (a) $CH_3CH(CH_3)CH_2Cl$ (1) $AlCl_3$ / $FeCl_3$ (1) Room temperature / in the dark (1) [3]

(b) (i) 2,4-DNP (1) Orange precipitate (1) [2]

(ii) Tollen's reagent (1) Silver mirror with **C**, no reaction with **B** (1) [2]

(c) Optical isomerism is where a molecule and its mirror image are different / non-superimposable (1)

Compound **C** has a chiral centre / 4 different groups attached to one carbon atom (1)



(1)

The two isomers rotate the plane of polarised light in opposite directions (1) [4]

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

(d) Dilute acid (1) heat (1) hydrolysis (1) [3]

(e) Acidified potassium dichromate (VI) (1) / heat (1)

One step reactions are generally better as they have a better yield / there is waste in each stage (1)

Two step process may be cheaper / use more sustainable reagents/ may give a better yield in this case / produce less harmful waste materials / potassium dichromate may react with other parts of the molecule as well / may be easier to separate product (1)

Do not credit same idea twice e.g. if 'better yield' gains first mark, a different point is required to gain second mark [4]

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

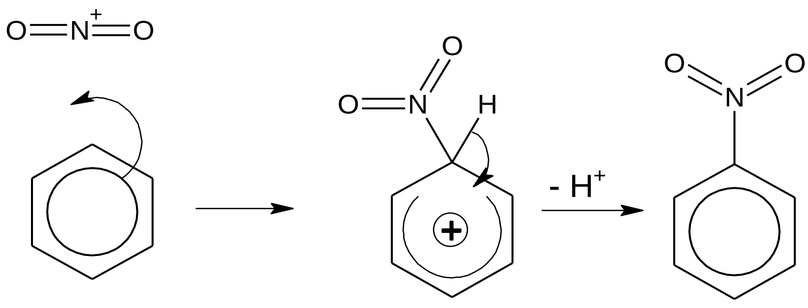
Total [20]

Q.5 (a) (i) Both molecules have lone pairs on nitrogen (1)

The lone pairs can form (coordinate) bonds with H^+ ions (1) [2]

(ii) Lone pair on N in phenylamine is delocalised over benzene ring (1) therefore less able to accept H^+ (1) [2]

(iii) I Arrow in first step (1)
Cation structure in second step (1)
Arrow in second step (1)

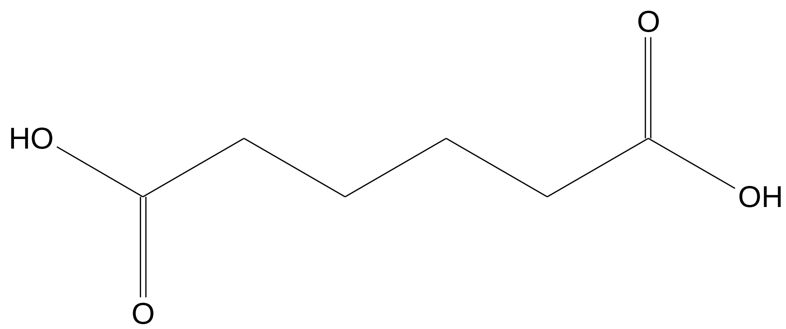


[3]

II (fractional) distillation / steam distillation [1]

III Sn and conc. HCl (1) followed by NaOH (1) [2]

(b) (i)



[1]

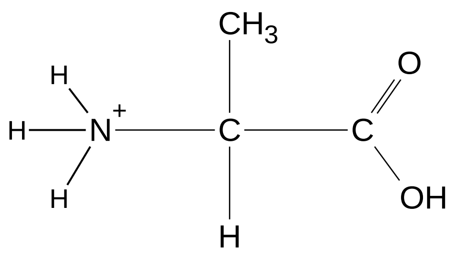
(ii) Addition polymerisation makes one product only /
Condensation produces one product plus a small molecule like water (1)

Addition polymerisation uses one starting material /
Condensation polymerisation has two different starting materials (1)

Addition polymerisation involves monomer with one functional group /
Condensation polymerisation involves monomer with two functional groups (1)

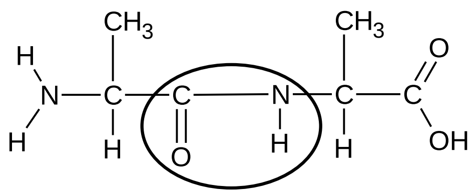
(max 2) [2]

(c) (i)



[1]

(ii)



[2]

(iii) Alanine has strong (electrostatic) forces between the zwitterions (1)

Butanoic acid has hydrogen bonding between molecules / electrostatic forces in alanine are stronger than forces in butanoic acid (1)

[2]

(iv) Soda lime (1) $CH_3CH_2NH_2$ (1) [2]

Total [20]

Total Section B [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