OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Mark Schemes for the Units

June 2007

3882/7882/MS/R/07

Oxford Cambridge and RSA Examinations

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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OCR Publications
PO Box 5050
Annesley
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CONTENTS

Advanced GCE Chemistry (7882)

Advanced Subsidiary GCE Chemistry (3882)

MARK SCHEME FOR THE UNITS

Mark Scheme 2811
June 2007

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

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ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

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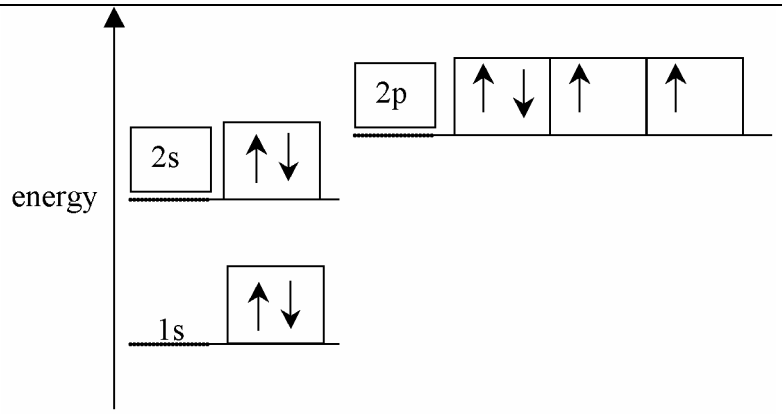
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Question	Expected answers	Marks
1 (a)	  1, 2 or 3 p orbitals are OK ✓ ✓	[2]
(b)	d orbital 2 ✓ p sub-shell 6 ✓ 3rd shell 18 ✓	[3]
(c) (i) (ii)	 2s and 2p labels ✓ Ignore any superscripted numbers. 8 electrons in correct levels with arrows correctly shown ✓	[2]
(d) (i)	Energy change when each atom in 1 mole ✓ of gaseous atoms ✓ loses an electron ✓ (to form 1 mole of gaseous 1+ ions).	[3]
(ii)	$O^{2+}(g) \longrightarrow O^{3+}(g) + e^-$ ✓✓ 1 mark for correct species; 1 mark for state symbols No charge required on electron. Ignore (g) on e	[2]
(iii)	Large difference between 6th and 7th IEs ✓ marking a different shell (closer to nucleus) ✓ *allow 'inner shells'/new shell/full shell/first shell* *marking points independent.* ***not** sub-shell or orbital*	[2]
		Total: 14

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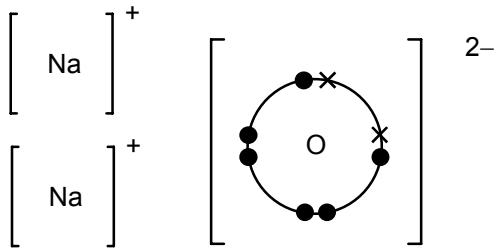
Question	Expected answers	Marks
2 (a) (i)	mass = 0.0500 x 23.0 = 1.15 g ✓	[1]
(ii)	moles H_2 = 0.0250 ✓ volume H_2 = 0.0250 x 24 = 0.600 dm^3 ✓ ecf from calculated moles H_2	[2]
(iii)	0.0500 mol in 50.0 cm^3 concentration = 0.0500 x 20 = 1.00 mol dm^{-3} ✓	[1]
(b)	 Also accept Na with full shell as long as it contains 'x's (as in example above) Ignore any inner shells correct dot and cross ✓ correct charges ✓	[2]
(c) (i)	$2Na + O_2 \longrightarrow Na_2O_2$ ✓	[1]
(ii)	$Na_2O_2 + 2H_2O \longrightarrow H_2O_2 + 2NaOH$ ✓	[1]
(iii)	correct covalent bonds shown ✓ electron count (14) for rest of molecule correct ✓	[2]
		Total: 10

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Question	Expected answers	Marks
3 (a)	add $AgNO_3$ /add Ag^+ ✓ ignore ammonia white (precipitate)/goes white/precipitate that dissolves in dilute $NH_3(aq)$ ✓ $Ag^+ + Cl^- \longrightarrow AgCl$ ✓ (ignore state symbols)	[3]
(b)	add NaOH ✓ $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$✓ or partial or completely ionic equation: $Cl_2 + 2NaOH \longrightarrow 2Na^+ + ClO^- + Cl^- + H_2O$/ $Cl_2 + 2OH^- \longrightarrow ClO^- + Cl^- + H_2O$✓	[2]
(c)	number of electrons /electron shells increases down group ✓ van der Waals' forces /induced dipole–dipole interactions ✓ forces greater $Cl_2 < Br_2 < I_2$ ✓	[3]
(d) (i)	(trigonal) pyramidal ✓	[1]
(ii)	electron pairs repel/bonds repel /electron pairs get as far apart as possible ✓ lone pairs repel more/forces 'them' closer ✓ 4 electron pairs surround central atom or N /diagram with 3 bonds and a lone pair ✓	[3]
		Total: 12

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Question	Expected answers	Marks
4 (a) (i)	They have different numbers of protons/ Ba has one more proton/Ba has 56 p^+; Cs has 55 p^+ ✓ (ignore electrons: any mention of 'neutrons' is wrong)	[1]
(ii)	s ✓	[1]
(iii)	Cs to Ba: nuclear charge increases/more protons ✓ electrons are in: the same shell/sub-shell/orbital /similar shielding/same shielding ✓ attraction increases/pull increases ✓ …….ORA	[3]
(iv)	smaller ✓ shell has been lost/less shielding/less electron repulsion/proton : electron ratio larger✓ mark separately	[2]
(b) (i)	loss (of electrons) ✓	[1]
(ii)	Ba ✓ 0 → (+)2 ✓ (accept 2+)	[2]
(iii)	Original solution contains ions/there are mobile ions ✓ Charge carriers removed as reaction takes place /as solid forms/ as $BaSO_4$ forms/as water forms ✓	[2]
(c)	M(BaO) = 137 + 16 = 153 ✓ moles BaO = 500/153 or 3.268 mol ✓ moles Ba = 3.268/2 or 1.634 ✓ mass Ba formed = 1.634 x 137 = 224 g ✓ accept 223.856209/223.86/223.9 g. if 6 mol BaO forms 3 mol Ba, award 3rd mark Alternative method mass 6BaO=918 g ✓ mass 3Ba = 411 g ✓ 1g BaO forms 411/918 g Ba ✓ 500 g BaO forms 223.856209/223.86/223.9 g Ba ✓	[4]
		Total: 16

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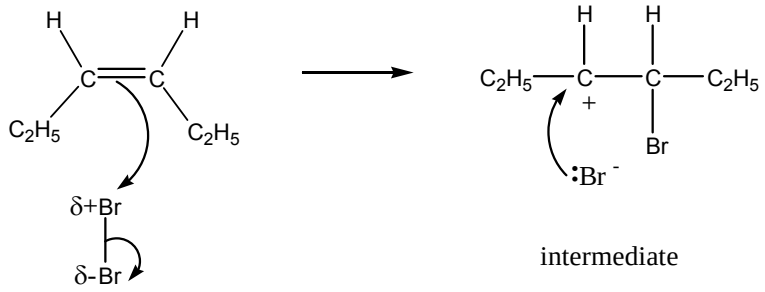
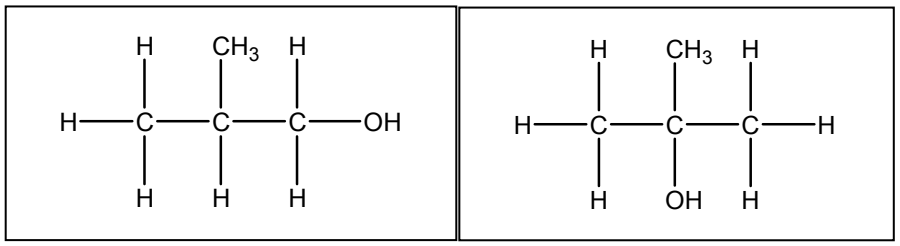
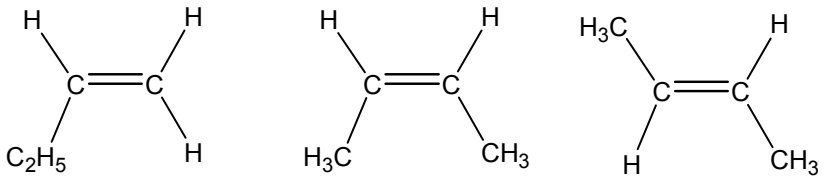
Question	Expected answers	Marks
5	**general** NaCl: ionic/has ionic bonds ✓ **Beware of contradictions for this mark, especially reference to intermolecular forces.** **Ignore 'atoms'.** graphite: covalent/giant molecular/macromolecular ✓ **Ignore van der Waals', intermolecular, molecules** **----------** **conductivity** NaCl: ions cannot move/ no free ions (or electrons) / mobile ions only in solution or when molten✓ graphite: delocalised electrons/ free electrons (between layers)/ electrons conduct ✓ **Ignore lone pair**	[2] [2]
	melting point **both** graphite and NaCl: bonds are strong/ bonds difficult to break / large amount of energy is needed to break bonds ✓	[1]
	solubility NaCl: Water is polar/water has a dipole/ ions interacts with water molecules ✓ Graphite: no interaction with water/ no intermolecular forces with water/ graphite is non-polar ✓	[2]
	QWC: At least 2 complete sentences in which the meaning is clear. ✓	[1]
	Total	**8**

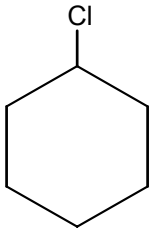
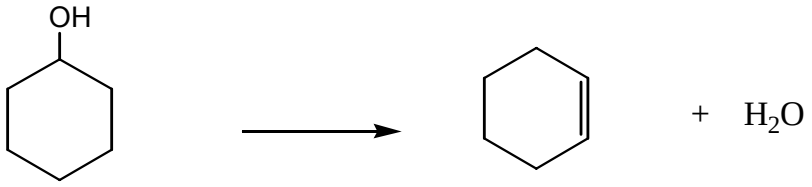
Mark Scheme 2812
June 2007

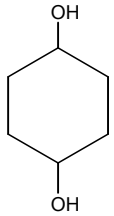
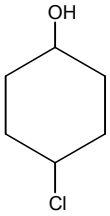
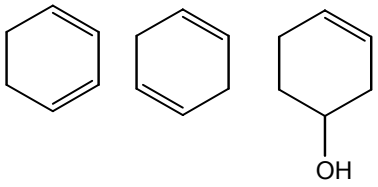
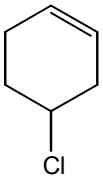
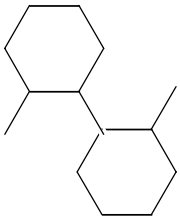
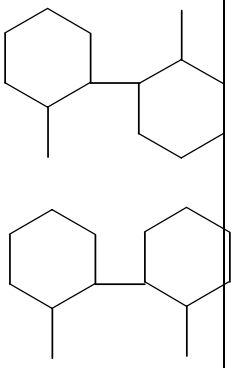
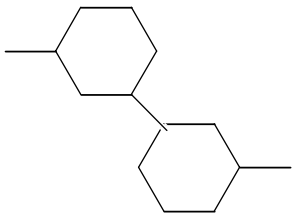
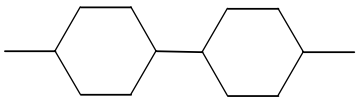
Question		Expected answers	Marks
1 (a)	(i)	$Br_2 \longrightarrow Br\bullet + Br\bullet$	✓
	(ii)	$Br_2 \longrightarrow Br^+ + Br^-$	✓
	(iii)	Br• (penalise lack of dot only once)	✓
		Br^- (give Br: as ecf if in (ii))	✓
1 (b)	(i)	(free radical) substitution	✓
	(ii)	1-bromohexane, 2-bromohexane and 3-bromohexane	✓✓✓
1 (c)		 intermediate	
		curly arrow from a lone pair on Br to the δ+ Br	✓
		dipoles shown correctly on the Br–Br and curly arrow from the Br–Br bond towards the $Br^{\delta-}$	✓
		correct intermediate shown	✓
		curly arrow from the lone pair or the negative charge on the Br^- to the C+	✓
1 (d)	(i)	Hs are diagonal to each other in the *trans*/ difference clearly shown in a diagram	✓
	(ii)	(the product is saturated hence) there is no restricted rotation/single bonds allow rotation/because C=C prevents rotation	✓
		Total	**14**

Question		Expected answers	Marks
2 (a)	(i)		✓✓
	(ii)	either (2-)methylpropan-1-ol or (2-)methylpropan-2-ol	✓
2 (b)		 Minimum – must display/show C=C	✓✓✓
2 (c)	(i)	$CH_3CH_2CH_2CH_2OH + Na \longrightarrow CH_3CH_2CH_2CH_2ONa + ½H_2$ C_4H_9OH/ $C_4H_{10}O$	✓
	(ii)	fizzes/effervescence/bubbles/gas evolved/H_2(g)/sodium dissolves/ disappears/sinks not just H_2 formed	✓
2 (d)	(i)	H^+ $Cr_2O_7^{2-}$	✓ ✓
	(ii)	Orange to green/black/blue	✓
2 (e)	(i)	contains a C=O/aldehyde, ketone, carboxylic acid and ester/ carbonyl/carbonyl in an aldehyde	✓
	(ii)	does **not** contain a O–H/ (hydrogen bonded in a) carboxylic acid	✓
	(iii)	distillation (no mark) **because** distillation allows loss of volatile components /removes butanal from oxidising mixture prevents formation of RCOOH/ partial oxidation would be achieved or reverse argument for reflux not being used in that reflux prevents loss of volatile components hence complete oxidation would be achieved/RCOOH would be formed ✓	✓ ✓
		Total	**15**

Question		Expected answers	Marks
3 (a)	(i)	water/aqueous	✓
	(ii)	(nucleophilic) substitution/ hydrolysis	✓
	(iii)	ethanol/ ethanolic/alcohol/methanol	✓
	(iv)	elimination	✓
(b)	(i)	lone/electron pair donor	✓
	(ii)	rate increases C–Br/bromine (not Br_2) bond weaker/longer or –Cl bond is stronger/shorter 1 ecf mark ……If they conclude the rate is slower (no mark) because C–Cl bond is more polar/Cl more electronegative (1 mark)	✓ ✓
		Total	**7**

Question		Expected answers	Marks
4		Recognises that either a catalyst or high temperature (heat is not sufficient) is required **cracking** suitable balanced equation **reforming** equation or statement indicating formation of a ring/cyclic compound suitable balanced equation with H_2 (balanced equation showing formation of a ring scores both marks) **isomerisation** suitable balanced equation The **processed products** are: • used in fuels/used in petrol • better /more efficient fuels/increase octane number/rating • alkenes (from cracking) produce polymers/alcohols • H_2 used for Haber process/fuels/hydrogenation of oils QWC SPAG – look for two complete sentence that present a coherent argument	✓ ✓ ✓ ✓ ✓ ✓✓✓ ✓
		Total	**9**

Question		Expected answers	Marks
5 (a)	**(i)**	C_6H_{10}	✓
	(ii)	C_3H_5 / ecf to (i)	✓
	(iii)	M_r of cyclohexene = 82 % C = (72/82) x 100 = 88% 87.8% gets 1 mark ecf to (i) and (ii) for both marks Alternative calculation based on empirical formula: Mass of empirical unit = 41, % C = (36/41) x 100 = 88%	✓ ✓
(b)		H_2 Ni/Pt/Pd (catalyst)	✓ ✓
(c)	**(i)**		✓
	(ii)	H_2SO_4/Al_2O_3/(hot) pumice/H_3PO_4 (H_2SO_4(aq) or dil H_2SO_4 loses the mark)	✓
	(iii)	 $C_6H_{11}OH$ / $C_6H_{12}O$ → C_6H_{10} + H_2O	✓

Question		Expected answers	Marks
5 (d)	(i)	 diol also allow  Cl-alcohol	✓
	(ii)	from the diol allow  from the Cl-alcohol allow 	✓✓
(e)	(i)	Addition (not additional)	✓
	(ii)	Correct polymer gets two marks Ideally  but accept any of  The two rings must be linked by adjacent carbons on the ring One mark can be awarded if two rings are linked together incorrectly, as shown below  	✓✓
		Total	**15**

Mark Scheme 2813/01
June 2007

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1 **(a)** F ✓ **[1]**

(b) E ✓ **[1]**

(c) G ✓ **[1]**

(d) A and F ✓ **[1]**

(e) temperature in range 200 to 600 ^{o}C/ 473 to 873 K ✓
ressure in range 25 to 1000 atm / 2500 to 100000 kPa/ 2.5 to 100 MPa ✓ **[2]**

[Total: 6]

2 **(a)** **(i)** (enthalpy change) when 1 mole of compound is formed ✓
from the constituent elements ✓
[2]

(ii) $6C(s) + 7H_2(g) \rightarrow C_6H_{14}(l)$
correct formulae and balancing ✓
tate symbols ✓ **[2]**

(iii) temperature 25^{o}C/ 298K/ a stated temperature (if justified)
pressure 1 atm/ 100 kPa/ 101 kPa ✓ **[1]**

(b) diagram to show
lines to show energy level at start above that at end of reaction ✓
ΔH labelled between reactants and products ✓

E_a labelled from reactants to top of energy 'hump' ✓ **[3]**

(c) correct Hess' cycle ✓
$x - 890 = -572 - 394$ ✓
$x = -76$ (kJ mol^{-1}) ✓ **[3]**

(d) **(i)** 1652/4 = 413 (kJ mol^{-1}) ✓ **[1]**

(ii) (C̃C) + 6 (C̃H) = 2825 ✓
(C̃C) = 2825 – 6(413) = 347 (kJ mol^{-1}) ✓ **[2]**

[Total: 14]

3 **(a)** when the conditions on a reaction in **equilibrium** are **changed/ disturbed** ✓

the (equilibrium) moves in the direction to minimise the effects of the change ✓ **[2]**

(b) **(i)** equilibrium moves to the LHS/ more X_2 and Y_2 are produced ✓

more moles (of gas)/ particles on LHS ✓ **[2]**

(ii) rate becomes less as there are less particles in a unit volume/ concentration less/ more space between particles ✓

therefore there are less (frequent) collisions ✓ **[2]**

(c) **(i)** 16–17 % ✓ **[1]**

(ii) as the temperature increases the conversion decreases ✓

(equilibrium) has moved to LHS/ has moved in endothermic direction ✓ **[2]**

(d) **(i)** increases ✓

because more collisions exceed (lowered) E_a/ because the catalyst provides an alternative route with a lower activation energy ✓ **[2]**

(ii) no change ✓

forwards and reverse rates increased by **same** amount ✓ **[2]**

[Total: 13]

4 **(a)** an acid is a proton donor/ H^+ donor/ electron pair acceptor ✓

a weak acid is partially dissociated **and** a strong acid is completely dissociated ✓

$HCl \rightarrow H^+ + \bar{C}l$ ✓

$C_2H_5COOH \rightleftharpoons H^+ + C_2H_5COO^-$ ✓

[4]

allow → or $\rightleftharpoons$ in both cases

(b) observations

bubbles seen/ fizzing/ effervescence/ gas evolved ✓

magnesium dissolves/ disappears ✓

slower/ longer reaction time for the weak acid ✓ ora

equations

equation for example with hydrochloric acid/ other suitable strong acid ✓

equation for example with propanoic acid/ other suitable weak acid ✓

accept correct ionic equation for 2 marks

explanation

due to lower **concentration** of H ✓ **[6]**

(c) $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$

water and carbon dioxide as products ✓

fully correct equation ✓ **[2]**

[Total: 12]

Mark Scheme 2813/03
June 2007

Plan

Equations must be written correctly in terms of subscripts ***and*** upper/lower case.
However, each type of error is penalised only once in the Plan (if equation is otherwise correct).
Accept any valid type of organic formula (or "hybrids") provided that functional group is shown.
Ambiguous tests, or tests that use the same reagent twice, score a maximum of one mark (out of 2).
Each bullet point scored is indicated by a dot.
There are 18 marks available for the Plan, but a maximum of 16 can be awarded.

A Bromoethane – *2 marks*

Two bullet points scored = 1 mark (A1)
*Four bullet points scored (out of **five** available) = 2 marks (A1 and A2)*

- add silver nitrate *(full name or correct formula required)*
- reagent or substrate is dissolved in [aqueous] ethanol ***or*** add NaOH
- cream/off-white precipitate [slowly] formed
- equation for reaction: $C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr + H_2O$
- equation (ionic ***or*** "molecular") for precipitation reaction: $Ag+ + Br^- \rightarrow AgBr$

B Cyclohexene – *2 marks*

Two bullet points scored = 1 mark (B1)
*Four bullet points scored (out of **five** available) = 2 marks (B1 and B2)*

- add bromine (*ignore any reference to a solvent*) ***or*** acidified $KMnO_4$
- mixture goes colourless/decolourised (*but not "clear"*)
- equation: $C_6H_{10} + Br_2 \rightarrow C_6H_{10}Br_2$ ***or*** $C_6H_{10} + [O] + H_2O \rightarrow C_6H_{10}(OH)_2$
- this is an addition reaction ***or*** double bond opens up to become single bond
- this reaction is a test for an alkene ***or*** for C=C

C Ethanoic acid – *2 marks*

Two bullet points scored = 1 mark (C1).
Four bullet points = 2 marks (C1 and C2)

- name of suitable test reagent *(e.g. magnesium)*
- observation made *(e.g. fizzing)*
- equation for reaction (*e.g.* $Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$)
- identity of observed product *(e.g. hydrogen)*

Other alternative reagents, such as use of sodium hydrogencarbonate, sodium carbonate or ethanol (for esterification) were awarded full credit.

D Butan-1-ol – *2 marks*

Two bullet points scored = 1 mark (D1)
*Four bullet points (out of **five** available) = 2 marks (D1 and D2)*

- identity of reagent *(e.g. potassium dichromate(VI) - oxidation state is **not** required)*
- conditions for test *(e.g. heat/reflux **and** acidify)*
- observation made *(e.g. goes green)*
- explanation of test *(e.g. [named] aldehyde/ carboxylic acid formed)*

- equation for reaction chosen
  e.g. $C_4H_9OH + 2[O] \rightarrow C_3H_7COOH + H_2O$ ***or*** $+ [O] \rightarrow C_3H_7CHO + H_2O$

E Methylpropan-2-ol – *3 marks*

Two bullet points scored = 1 mark (E1)
Four bullet points = 2 marks (E1 and E2)
Six bullet points = 3 marks (E1, E2 and E3)

- identity of suitable test reagent
  e.g. concentrated hydrochloric acid (This is the *Lucas test*)
- conditions for test
  e.g. zinc chloride [used as catalyst]
- observation made
  e.g. cloudiness formed *(allow "precipitate")*
- simple explanation (etc)
  e.g. rapid reaction [in Lucas test] indicates a tertiary alcohol
- correct equation
  e.g. $C_4H_9OH + HCl \rightarrow C_4H_9Cl + H_2O$
- correct structural *or* displayed formula of methyl propan-2-ol given
  e.g. $(CH_3)_3COH$ *or* $CH_3C(CH_3)(OH)CH_3$

Other reagents are suitable for identifying both of the alcohols, depending on the sequence in which the unknowns were identified

F Water – *2 marks*

F1 Add white/anhydrous copper sulphate → blue
or add blue/anhydrous cobalt chloride → pink **[1]**

F2 Equation for reaction **[1]**

$CuSO_4 + 5H_2O \rightarrow CuSO_4.5H_2O$ ***or*** $CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$

G Flow chart – *1 mark*

G1 A clear accurate flow chart is given for the whole sequence **[1]**

Award mark G1 only if the chart validly identifies at least 5 compounds.

S Safety, Sources and QWC – *4 marks*

S1 **Safety**: **One** significant relevant hazard ***and*** a specific safety procedure described.
Hazard quoted must be related to the reaction described
(e.g. no credit for "Mg is flammable" since it is not heated)
Safety procedure must be ***specifically linked to stated hazard***
- *alcohols are flammable so use a water bath/reflux apparatus to heat*
- *dichromate(VI) is toxic/carcinogenic so wear gloves*

These are only examples of correct ideas which would earn S1 **[1]**

S2 **Two sources** quoted in the text ***or*** at end of Plan. **[1]**
- *Book references* ***must*** *have chapter or page numbers*
- *Internet reference must go beyond the first slash of web address* S3

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate **[1]**
Awarded if there are fewer than six errors in legibility, spelling, punctuation or grammar.

S4 **QWC**: information is organised clearly and coherently **[1]**

- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language used correctly?*
- *Is the written material submitted relevant to the task set?*

Practical Test

Page 3 **Skill I - 16 marks**

Mass readings **[2]**

- Both mass readings must be listed with unit (g) shown
- Subtraction to give mass of E must be correct.
- Mass of E used must be greater than 1.20g
- All three masses should be recorded to two (or three/four, consistently) decimal places
- Labelling of masses must have minimum of the words "bottle"/"container" (*aw*)

Five bullets correct = 2 marks ***Four bullets correct = 1 mark***

Presentation of titration data **[2]**

- Correctly labelled table (initial, final and difference - *aw*) used to record burette data
- A table grid must be **drawn (**two lines minimum) ***and*** all data must be presented in the table.
- **All** "accurate" burette data are quoted to two decimal places (ending in .00 or .05)
- All subtractions are correct

Four bullets correct = 2 marks ***Three bullets correct = 1 mark***

Self-consistency of titres **[2]**

- Two ***or*** three titres are ticked
- The [ticked] titres are within 0.20 cm^3
- The [ticked] titres are within 0.10 cm^3
- Units, cm^3 or ml, must given somewhere ***(once in or alongside the table is sufficient).***

Four bullets correct = 2 marks
Three bullets correct = 1 mark

Mean titre correctly calculated **[1]**

Accuracy – 7 marks

Use the conversion chart below to award the mark out of 7 for accuracy.
Adjusted candidate's titre, T = mean titre x $^{\text{supervisor's mass}}/_{\text{candidate's mass}}$

T is within **0.25 cm^3** of mean supervisor's value	**[7 marks]**
T is within **0.40 cm^3** of mean supervisor's value	**[6]**
T is within **0.80 cm^3** of mean supervisor's value	**[4]**
T is within **0.60 cm^3** of mean supervisor's value	**[5]**
T is within **1.00 cm^3** of mean supervisor's value	**[3]**
T is within **1.20 cm^3** of mean supervisor's value	**[2]**
T is within **1.50 cm^3** of mean supervisor's value	**[1]**

Note*: if the supervisor's mean titre was less than 20.0 cm^3, a stricter scale was adopted.*

Safety – 2 marks

E is corrosive ***or*** causes burns **[1]**

Diluting the acid/ making less concentrated/ adding water [reduces the level of hazard] **[1]**

Page 4 (Part 2) – 6 marks

Penalise incorrect sig fig on the first occasion only, if the answer is otherwise correct.

2 **(a)** M_r of NaOH = 40 **[1]**

[NaOH] = 0.105 mol dm^{-3} **[1]**

2 **(b)** $n(NaOH) = {}^{cV}/_{1000}$ [= *0.002 mol (approx)*] **[1]**
*This is a **method** mark (for correct use of answer (a) **and** the mean titre volume).*

2 **(c)** CH_3COONa and H_2O shown ***and*** no balancing figures (***or*** all "1") **[1]**

State symbols:aq, aq, aq, l **[1]**

*If the products of reaction are incorrect, the state symbols mark is **not** available*

2 **(d)** $n(CH_3COOH)$ = same answer as "b" **[1]**

Page 5 (Part 2) – 8 marks

2 **(e)** $n(CH_3COOH)$ = 10 x "d" **[1]**
*This mark is for the **method**, not for the answer obtained*

2 **(f)** M_r of ethanoic acid = 60 **[1]**

mass of [pure] ethanoic acid = calculated M_r x (e) **[1]**

2 **(g)** % purity = $^{(f)}/_{\text{actual mass of E used}}$ x 100 **[1]**
*This is a **method** mark for using the appropriate figures*

Answer correctly calculated **[1]**

2 **(h)** **(i)** The impurity is not acidic *or* impurity is not alkaline *or* impurity is neutral/inert **[1]**

If the impurity were acidic, it would increase the titre/react with NaOH
or an alkaline impurity would react with the ethanoic acid/reducing the titre
or If impurity is neutral it would not react with NaOH **[1]**

(ii) Water ***or*** carbon dioxide **[1]**

Page 6: Part 3: Evaluation **[14 marks]**

*Award maximum **14 marks** in the section (17 marks available)*

3 a) 2 marks

Titration was repeated ***or*** the gas collection experiment was not repeated **[1]**

Readings are reliable if they are consistent ***or*** within 0.1 cm^3 **[1]**

3 (b) 3 marks

n(ethanoic acid) = 0.005(0) mol **[1]**

M_r of $NaHCO_3$ = 84 **[1]**

Mass of $NaHCO_3$ used was **not** sufficient ***and*** explanation including use of 1:1 mole ratio **[1]**

3 (c) 12 marks available *(but 9 shown on question paper)*

*Award marks for the candidate's best **three** strands*

C1 Mass of ethanoic acid used was very/too small *or* use more ethanoic acid **[1]**

C2 The <u>percentage</u> error in this measurement is therefore high **[1]**

C3 % error in measurement of the mass of acid correctly calculated
Accept $^{100 \times 0.01}/_{0.30}$ = 3.3% or $^{100 \times 0.02}/_{0.30}$ = 6.7% **[1]**

C4 Increase masses of <u>both</u> reagents used *or* use a balance reading to 3 decimal places **[1]**

D1 Gas will escape while the bung is being fitted to the flask

or insertion of bung displaces some air **[1]**

D2 Use an ignition tube as an inner tube (*or* alternative valid method) **[1]**

D3 This keeps reagents separate/ stops reaction commencing too soon **[1]**

D4 Shake/invert flask in order to mix reagents [and start reaction] **[1]**

E1 250cm^3 measuring cylinder is inaccurate for measurement of small volume/40 cm^3 of gas **[1]**

E2 Reasonable attempt to show calculation of % error in volume of gas measured **[1]**
e.g. % error = $^2/_{40}$ x 100 = 5% or % error = $^5/_{40}$ x 100 = 12.5%

E3 Replace with an [inverted] burette /gas syringe/ smaller measuring cylinder **[1]**

E4 Reason for choice of alternative collection **[1]**

Allow narrower bore or more accurate graduations or greater % accuracy

F1 Carbon dioxide is [slightly] soluble in water **[1]**

F2 Use a smaller volume / less than 10 cm^3 of water <u>in the reaction flask</u> **[1]**

F3 Collect in a gas syringe [instead of over water]
or use a liquid for collection in which CO_2 is less soluble
or pre-saturate the [collection] water with CO_2 **[1]**
Accept use of hot water for collection

G1 Reaction is very slow ***or*** will not be complete after one minute **[1]**

G2 Use a smaller volume of water in the reaction flask
or shake/swirl/stir flask during reaction or add catalyst **[1]**

G3 This change speeds up reaction
or measure final volume only when fizzing stops/volume stops increasing **[1]**
An observation is required, not merely "allow reaction to finish"

H1 Temperature of the gas collected is not exactly $20^oC/25^oC$/room temperature **[1]**
One mark only is awarded for this strand

Mark Scheme 2814
June 2007

INSTRUCTIONS ON MARKING SCRIPTS

For many question papers there will also be subject or paper specific instructions which supplement these general instructions. The paper specific instructions follow these generic ones.

All scripts must be marked in accordance with the version of the final mark scheme agreed at the standardisation meeting.

Annotation of scripts

The purpose of annotation is to enable examiners to indicate clearly where a mark is earned or why it has not been awarded. Annotation can, therefore, help examiners, checkers, and those remarking scripts to understand how the script has been marked.

Annotation consists of:

- the use of ticks and crosses against responses to show where marks have been earned or not earned;
- the use of standard abbreviations as follows;

×	=	incorrect response (errors may also be underlined)
^	=	omission of the correct response
bod	=	"benefit of the doubt" (where professional judgement has been used in deciding a response is worthy of a mark)
ecf	=	"error carried forward" (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response). No mark awarded, even if one response was correct. [1]
sf	=	error in the number of significant figures (only penalised once on the paper).

Any other comments should be kept to a minimum and should always be specifically related to the award of a mark or marks and be taken (if appropriate) from statements in the mark scheme.

Where annotations are put onto the candidates' script evidence, they should normally be recorded in the body of the answer or in the margin immediately adjacent to the point where the decision is made to award or not award the mark.

Recording of marking: the scripts

i) Marked scripts must give a clear indication of how marks have been awarded as instructed in the mark scheme.
ii) All numerical marks for responses to part questions should be recorded un-ringed in the right-hand margin. The total for each question (or, in specified cases, for each page or section) should be shown as a single ringed mark in the right-hand marking at the end of the question.
iii) The ringed totals should be transferred to the front page of the script, where they should be totalled.
iv) Every page of a script on which the candidate has made a response should show evidence that the work has been seen.
v) Every blank page should be crossed through to indicate that it has been seen.

[1] Note that in organic chemistry a candidate may identify a compound by name and formula. If one of these is wrong then the mark is not awarded, as this is a contradictory answer.

Handling of unexpected answers

The standardisation meeting will include a discussion of marking issues, including:

- a full consideration of the mark scheme with the objective of achieving a clear and common understanding of the range of acceptable responses and the marks appropriate to them;
- the handling of unexpected, yet acceptable answers.

There will be times when you may not be clear how the mark scheme should be applied to a particular response. In these situations an element of professional judgement is required. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in any doubt, a telephone call to the Team Leader should produce a speedy resolution to the problem.

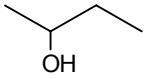
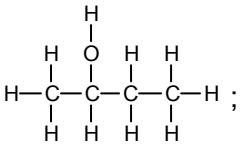
Particular instructions relating to marking organic chemistry papers

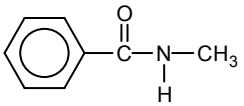
i) Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated on the mark scheme. (An instruction to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

ii) If a candidate lists more than one possible answer in questions requiring reagent(s) and/or condition(s) for a reaction, the wrong answers are marked first up to the maximum marks available for reagents/conditions.

iii) When a structure is asked for, there must be sufficient detail using conventional carbon skeleton and functional group formulae (e.g. CH_3, C_2H_5, OH, COOH, $COOCH_3$) to unambiguously define the arrangement of the atoms. (e.g. C_3H_7 would not be sufficient).

If not specified by the question, this may be given as either:

- a **structural formula** – e.g. $CH_3CH(OH)C_2H_5$;
- a **skeletal formula** – e.g.  ;
- a **displayed formula** – e.g.  ;

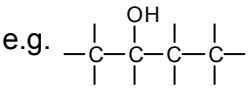
or as a hybrid of these – e.g.  .

Benzene rings in any of the types of formula above may be represented as  **as well as** 

iv) The following errors should be penalised – although each one only loses a maximum of one mark on the paper:

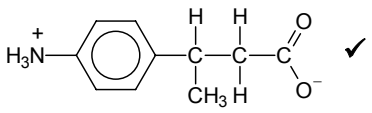
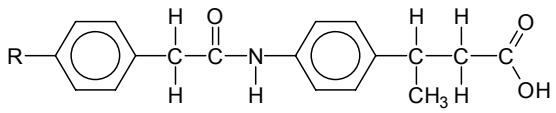
- clearly connecting a functional group by the wrong atom

- showing only ‘sticks’ instead of hydrogen atoms –

e.g. 

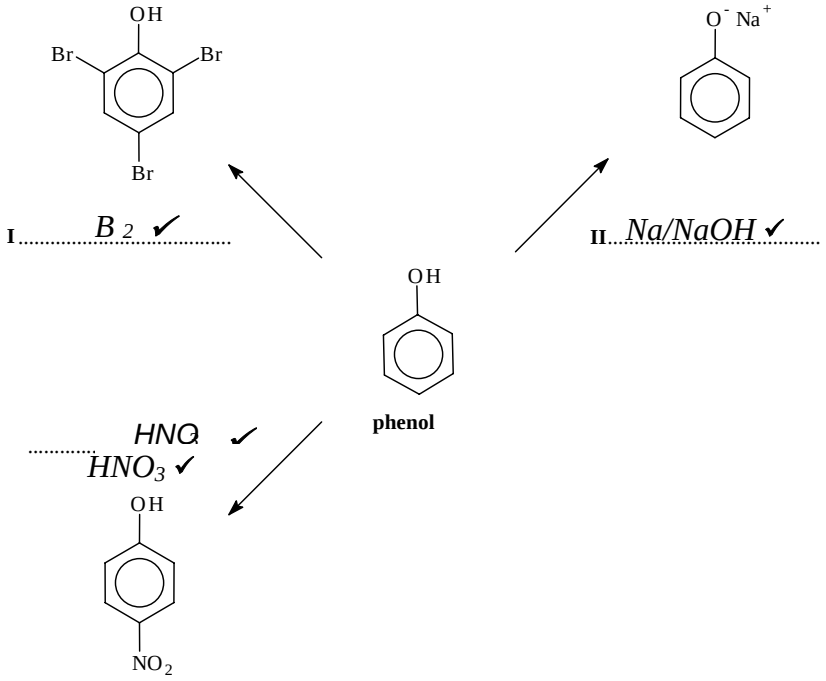
Abbreviations, annotations and conventions used in the mark scheme

/	alternative and acceptable answers for the same marking point
;	separates marking points
NOT	answers not worthy of credit
( )	words that are not essential to gain credit, but should not be contradicted
___	(underlining) key words which must be used for the mark
ecf	allow error carried forward in consequential marking
AW	alternative wording with the same meaning gains credit
ora	or reverse argument

Question	Accepted answers	Marks
1 (a) (i)	is an amine and a carboxylic acid / contains both NH_2 and COOH functional groups ✓ **AW**	[1]
(ii)	$RCH(NH_2)COOH$ ✓ Does not fit the formula because NH_2 and COOH are not attached to the same carbon ✓ **AW**	[2]
(b) (i)	$CH_3CHClCH_2COOH + C_6H_6 \longrightarrow C_6H_5CH(CH_3)CH_2COOH + HCl$ ✓	[1]
(ii)	(electrophilic) substitution / Friedel–Crafts ✓	[1]
(iii)	$FeCl_3$ / $AlCl_3$ ✓	[1]
(c) (i)	 ✓	[1]
(ii)	–COO^- becomes –COOH ✓ (rest of structure unaffected)	(allow ecf on rest of the structure) [1]
(d)	 displayed peptide bond ✓ rest of the structure also correct ✓	(allow full marks for a correct anhydride structure) [2]
		[Total: 10]

Question	Expected answers	Marks

2 (a) (i)



(do not allow a halogen carrier with the bromine)

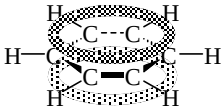
(do not penalise use of a nitrating mixture)

[3]

(ii) dye / colouring / indicator ✓ **[1]**

(iii) phenylamine ✓
$NaNO_2$ / HNO_2 ✓ + HCl ✓
< 10°C ✓
add to alkaline phenol ✓ **[5]**

(b) **bonding in benzene**
overlap of p-orbitals / π bonds/electrons (or labelled) ✓



above and below the ring (or shown in a diagram) ✓

electrons are <u>delocalised</u> (or labelled) ✓
C–C bonds are: same length/strength / in between single and double / σ-bonded **AW** ✓

greater reactivity of phenol
(the ring is activated because …)
<u>lone</u> pair from O is delocalised into the ring ✓
so electron density (of the ring) is increased ✓
so electrophiles are more attracted (to the ring) / dipole in electrophile more easiy induced ✓

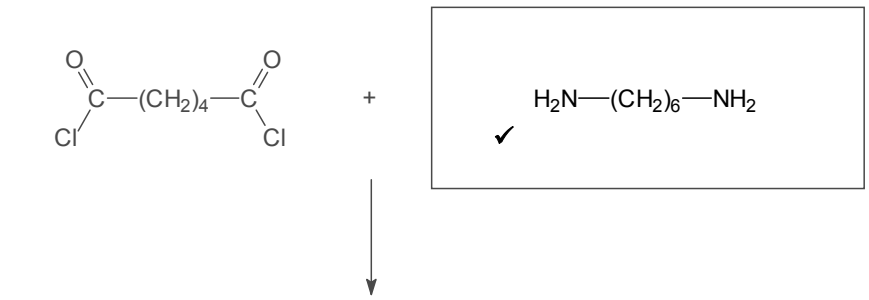
*(**NOT** just more easily "attacked" or "susceptible")*

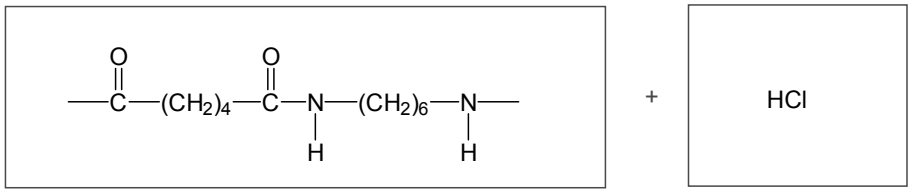
Quality of written communication mark for at least two complete sentences in which the meaning is clear with correct spelling, punctuation and grammar ✓ **[8]**

[Total: 17]

Question	Expected answers	Marks

3 (a) (i)



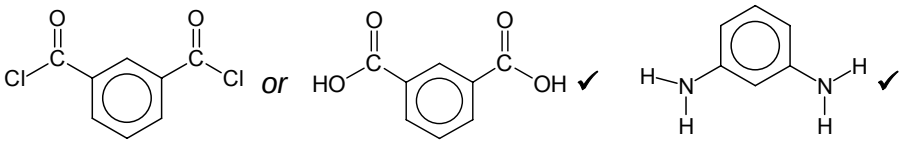


(allow ecf on the carbon skeleton of the diamine)

peptide bond displayed ✓
correct repeat ✓
✓

[4]

(b) (i)

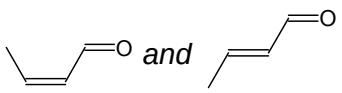
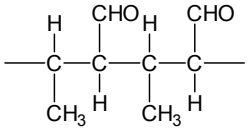


[2]

(ii) any valid suggestion to explain or describe stronger intermolecular forces – *e.g.* Nomex is planar so packs together more easily / greater H-bonding / Van der Waals' / forces between molecules ✓**AW**
(ignore arguments based on M_r)

[1]

[Total: 7]

Question	Expected answers		Marks
4 (a) (i)	 *and* at least one correct skeletal formula ✓ correct *cis* and *trans* isomers of but-2-enal ✓		[2]
(b) (i)	heat with: Tollens' reagent / ammoniacal silver nitrate ✓ to give: silver mirror / precipitate ✓		[2]
(ii)	aldehydes can be oxidised to a carboxylic acid **ora** / aldehydes can reduce Ag^+ to Ag ✓		[1]
(c) (i)	$CH_3CH=CHCH_2OH$ ✓	*(either stereoisomer)*	[1]
(ii)	reduction / redox / addition ✓	*(**NOT** hydrogenation)*	[1]
(d)	$C_4H_6O + \mathbf{5}O_2 \longrightarrow \mathbf{4}CO_2 + \mathbf{3}H_2O$ ✓		[1]
(e) (i)	 ✓		[1]
(ii)	random (3-d) arrangement of side chains / functional groups (along the chain) ***AW***		[1]
			[Total: 10]

Question	Expected answers	Marks

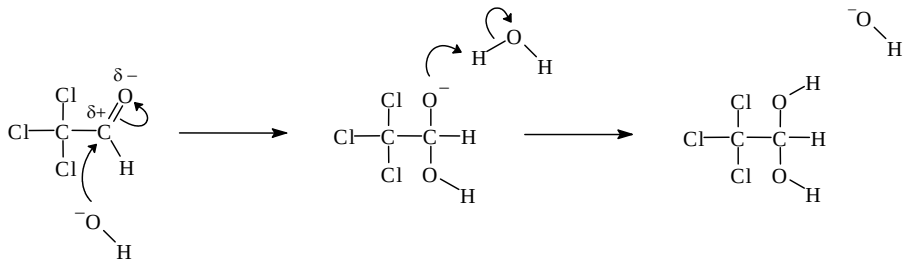
5 (a) (chloral hydrate because ….)

peak at ~3300 / in range 3230–3550(cm^{-1}) for O–H ✓

no peak at 1680–1750(cm^{-1}) for C=O ✓

peak at ~1050 / in range 1000–1300(cm^{-1}) for C–O ✓ **[3]**

(b)



curly arrow from O of $\ddot{O}H^-$ to C ✓

dipole on C=O and curly arrow breaking C=O ✓

structure of the intermediate ✓

curly arrow from $\ddot{O}$ (of the correct intermediate)
… to H of H_2O ✓ (allow $\ddot{O}$ to H^+ ion here)

curly arrow breaking the H–O bond in H_2O ✓ **[5]**

(c) one mark for the correct answer to each step below with ecf throughout
steps may come in any order

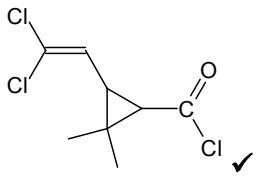
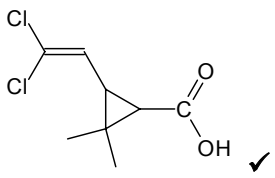
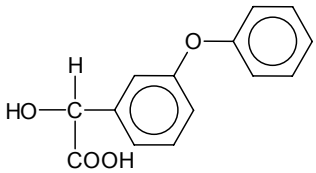
one week's supply = 21x dose ✓	5.25 g / 0.0317mol
mass of trichloroethanal = 0.891 x mass of chloral hydrate ✓	4.68 g (223mg if done first)
60% yield = mass/moles x 100/60 ✓	**7.8**(0 g)

[3]

common errors for two marks are: 9.82 g (mass ratio upside down)
8.75 g (mass ratio not done)
2.60 g (3x not done), 1.11 g (7x not done), 0.371g (21x not done)
7798 g (mg to g not done) *etc.*

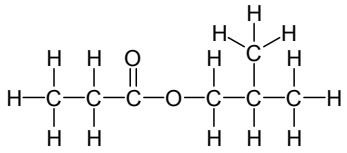
(d) $CCl_3CH(OH)_2 + [O] \longrightarrow CCl_3COOH + H_2O$ ✓ **[1]**

[Total: 12]

Question	Expected answers		Marks
6 (a) (i)	22 ✓		[1]
(ii)	 ✓		[1]
(iii)	ester ✓		[1]
(iv)	HCN (+ KCN) / strong acid + KCN ✓	*(allow HCN + alkali)*	[1]
(v)	(nucleophilic) addition ✓		[1]
(b)	(cypermethrin has) a chiral centre / is chiral ✓ enzyme / natural synthesis will make only one (optical) isomer ✓ **AW** **ora** ***either*** only one (stereo)isomer is active / has the right shape **AW** **or** the natural product is 100% active / synthetic is 50% active **AW** ✓	*(not "is useful")*	[3]
(c) (i)	(heat under) reflux ✓ with a suitable aqueous strong acid ✓	*(**NOT** HNO_3 and **NOT** conc H_2SO_4)*	[2]
(ii)	 ✓  COOH ✓ rest of the structure ✓		[3]
			[Total: 13]

Question	Expected answers	Marks

7 (a)



propanoate and ester group ✓ 2-methyl propyl ✓ **[2]**

(b) propanoic acid ✓
(2-)methylpropan-1-ol ✓

heat ✓
conc. H_2SO_4 ✓
(allow ecf from part (a) for the equation)

$CH_3CH_2COOH + (CH_3)_2CHCH_2OH \longrightarrow CH_3CH_2COOCH_2CH(CH_3)_2 + H_2O$
reactants ✓ products ✓ **[6]**

(c) mass spectrum / spectrometry ✓

molecular ion peak /
m/e or mass of the peak furthest right ✓ **AW** **[2]**

(d) (i) δ **value / chemical shift** gives the 'type' of proton / chemical environment ✓ **AW**
example quoted from data sheet ✓

number of peaks gives the number of different types of proton / chemical environments ✓

relative / ratio of ✓
peak areas gives the number of protons (of each type) ✓

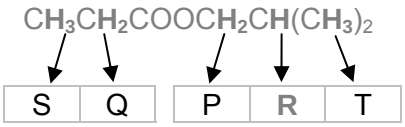
splitting gives number of neighbouring / adjacent protons ✓

description of $n + 1$ rule / example of doublet, triplet or quadruplet showing 1, 2 and 3 protons neighbouring (carbon) atom ✓ **AW**

D_2O can be used to identify OH groups ✓ ***ANY 7 marks out of 8*** **[7]**

Quality of written communication mark for correct use and organisation of at least **two** of the following technical terms:
proton, environment, singlet (doublet *etc*.), ppm, equivalent, chemical shift, splitting, labile, integration **[1]**

(ii)



one correct ✓ two correct ✓ four correct ✓ **[3]**

[Total: 21]

Mark Scheme 2815/01
June 2007

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

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Mark Scheme	Unit Code 2815/01	Session June	Year 2007	Version Final
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Question	Expected answers	Marks	Additional guidance
1 (a)	$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$ (1)	1	**State symbols must be correct** **Allow** any correct multiple of this equation. **Allow** Al_2Cl_6
(b)	$MgCl_2$ – (strong electrostatic) attraction between ions (1); $SiCl_4$ – (weak) van der Waals forces (1) Correct use of strong and weak – must be linked to the correct force/bond (1)	3	**Allow** ionic bonds / ionic lattice / 'is ionic' (1) **Allow** intermolecular forces / description of an intermolecular (1) **Allow** correct reference to simple **and** giant (1) if no other marks scored in this question
(c)	NaCl – ions are free/ ions can move (1); $SiCl_4$ – electrons cannot move / all electrons are in bonds / electrons are not free (1)	2	**Ignore** delocalised electrons **Ignore** no free ions **Not** $SiCl_4$ is ionic
		Total = 6	

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Question	Expected answers	Marks	Additional guidance
2 (a) (i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ (1)	1	
(ii)	Has an incomplete set of d electrons / partially filled d sub-shell / partially filled d orbital (1)	1	**Allow** partially filled d shell
(b) (i)	Has a (lone) pair of electrons that can be donated / lone pair that can form a dative bond / pair of electrons that can form a coordinate bond (1)	1	
(ii)	3D diagram of octahedral structure (1); Bond angle 90^o (1)	2	**Name** octahedral must be present to score two marks **Allow** use of wedges and dotted lines to indicate three dimensions **Allow** three dimensions if at least two bond angles of 90^o are shown that clearly demonstrate 3D **If two different bond angles** do not award bond angle mark
(c) (i)	Ligand substitution / ligand replacement (1)	1	
(ii)	Blood-red / red (1)	1	
(d) (i)	Brown / red-brown / foxy-red / rusty / orange ppt (1)	1	**Allow** solid instead of precipitate **Allow** state symbol (s) for precipitate
(ii)	$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$ Correct equation (1) State symbols for the correct formulae even if spectator ions are present (1)	2	**Allow** equations using the hydrated iron(III) ion
		Total = 10	

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Question	**Expected answers**			**Marks**	**Additional guidance**
3 (a) (i)	Ionisation energy refers to removing electrons that are attracted to the nucleus / energy needed to overcome the force of attraction between outer electrons and nucleus (1)			1	
(ii)	Electron affinity involves an electron(being gained) experiencing attraction to the nucleus (1)			1	
(b) (i)	Correct state symbols (1); Correct formula (1); Correct cycle with labelling or energy values (1)			3	**Allow** 1 error or omission in state symbols. Providing formula has correct state symbols once in cycle this is sufficient
(ii)	= +178 + 249 + 798 + (-141) + 1150 + 590 + (-3459) (1) =-635 kJ mol^{-1} (1)			2	Final answer must have correct units +635 kJ mol^{-1} scores 0
(iii)	Ionic radius of iron(II) less (than that of calcium ion) / charge density of Fe^{2+} greater (than that of Ca^{2+}) /. ora (1)			1	
				Total = 8	

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Question	**Expected answers**			**Marks**	**Additional guidance**
4 (a)	$Fe_2O_3 + 3Cl_2 + 10OH^- \rightarrow 2FeO_4^{2-} + 5H_2O + 6Cl^-$ (2)			2	**Allow** one mark if electrons shown **Allow** one mark if correct reactants and products but not balanced
(b)	Correct M_r for Fe_2O_3, 159.6, and of Na_2FeO_4,165.8 (1) Moles of Fe_2O_3 = 0.00627 (1); Mass of Na_2FeO_4 = 2.08 (1); Percentage = 21.6 or 21.7 (%) (1)			4	**Allow** full marks for correct answer with some working Answer **must** have 3 sig figs **Allow** ecf from wrong moles or wrong mass
(c)	Oxidation state of iron changes from +6 to +3 so is reduction (1) Oxidation state of oxygen changes from -2 to 0 so is oxidation (1) **OR** Oxidation state of iron changes from +6 to +3 and oxidation state of oxygen changes from -2 to 0 (1) Iron is reduced and oxygen is oxidised (1)			2	To get the two marks for oxidation states marks any other oxidation state quoted must be correct. Maximum one mark if any other oxidation number given is wrong **Allow** ecf from wrong oxidation states
(d) (i)	(Oxidised to) iodine so a brown (solution) formed / Fe^{3+} formed which is yellow or orange / Fe^{2+} formed which is green (1)			1	**Allow** red/brown or orange
(ii)	Nitrogen / N_2 (1)			1	**Allow** any correctly named oxide of nitrogen / correct formulae / HNO_3 etc.
				Total = 10	

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Question	Expected answers	Marks	Additional guidance
5	**Acid-base – maximum 3 marks** Acid-base reaction involves proton transfer / acids donate protons **and** bases accept protons (1); Equation (1) e.g. $MgO + 2HCl \rightarrow MgCl_2 + H_2O$; Observation (1) e.g. oxide forms a colourless solution **Hydrolysis – maximum 3 marks** Reaction with water / aw (1); Equation (1) e.g. $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$; Observation (1) e.g. white precipitate formed / steamy fumes formed / highly acidic solution formed **Thermal decomposition – maximum 3 marks** Reaction in which a compound is broken down (into at least two substances when heated) (1); Equation (1) e.g. $MgCO_3 \rightarrow MgO + CO_2$; Observation (1) e.g. white solid formed / colourless gas formed **And** One mark for three correct examples (even if equations are wrong or is a description or involves elements not in Period 3)) (1) **And QWC** One mark for correct spelling, punctuation and grammar in at least two sentences (1)	10	Examples must come from an element in Period 3. **Ignore** bond breaking on adding water / adding water
		Total = 11	

Mark Scheme 2815/02
June 2007

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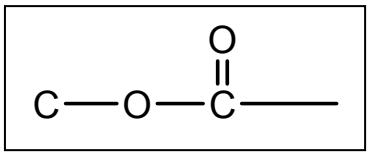
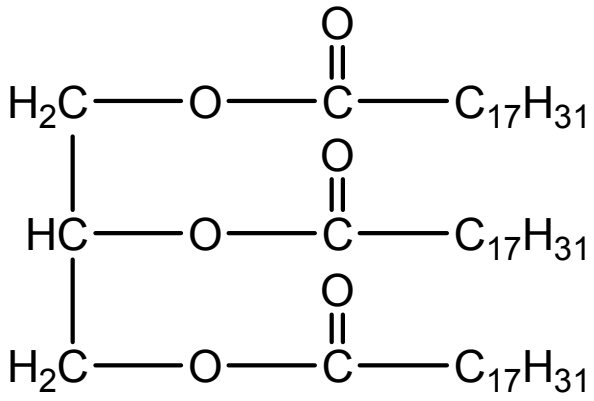
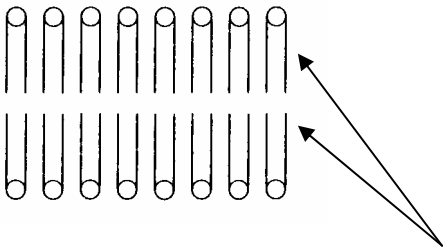
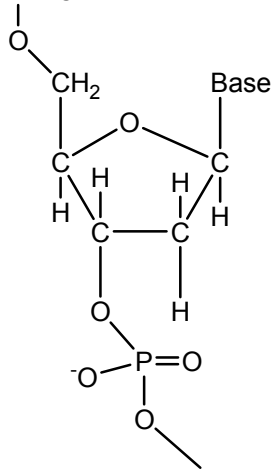
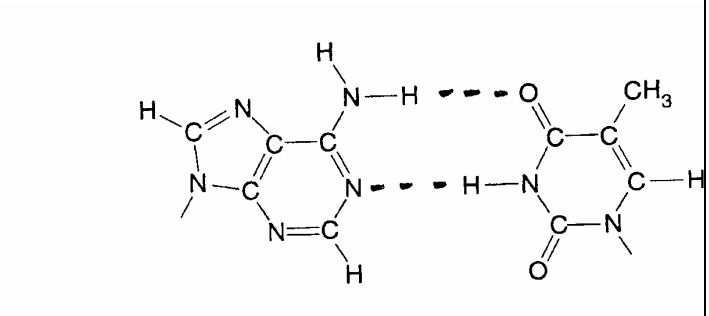
Question	Expected answers	Marks
1 (a)(i)	Circle round central O/round –O-/round C-O-C ✓	1
(ii)	α (in both) ✓. Numbering not required. Not 1α–4, not β anywhere	1
(b)(i)	Use of enzyme/trehalase/α-glucosidase✓ Allow use of acid (although it does not work well) including plain HCl but not conc. sulphuric acid.	1
(ii)	Glucose✓. Accept D-glucose. Ignore any reference here to α or β.	1
(c)	Any two marks from: ✓✓ • An H on water hydrogen bonded to –O–H • An H on water hydrogen bonded to ring/glycosidic O • An O on water hydrogen bonded to –O–H Max 1 mark if they hydrogen bond to C–H. Ignore partial charges, but full charges would be a CON.	2
(d)	No branches/ mention of lack of 1-6 links✓AW Accept repeating unit is a disaccharide rather than monosaccharide. AW	1 **Total 7**

Question	Expected answers	Marks
2.(a)(i)	✓ for a correct ester ✓ for rest   Accept correct skeletal form (even if only for acyl groups) but must have 17C and two double bonds/one triple bond	2
(ii)	6. Ecf from (i).✓	1
(b)	Three of following points: ✓✓✓ • 1. There is van der Waals (IDID) between triglycerides. • 2. There is van der Waals between triglycerides and (non-polar) solvent. • 3.Triglycerides cannot hydrogen bond (to water)(enough). • Because there are not enough suitable sites/oxygen atoms Or long hydrocarbon chains do not hydrogen bond/would interfere with hydrogen bonding in water AW	3
(c) (i)	Instead of one fatty acid/ carboxylic acid/acyl group✓ there is a phosphate✓ Not hydrocarbon alone.	2
(ii)	 Hydrocarbon chains must be labelled. Not a micelle.	1 **Total 9**

Question	Expected answers	Marks
3.(a)(i)	$HOH_2CCHOHCHOHCHOHCHOHCHO$ Aldehyde ✓ the rest ✓ Or vertical/displayed. If displayed all bonds must be shown correctly. Ignore stereochemistry. Accept a reversed OH group.	2
(ii)	Ester/lactone ✓ Not carbonyl.	1
(iii)	Allows enzyme to be stored for long periods/ ease of use (compared with test-tubes *etc.*}/ more stable (to higher temperatures/pH changes). AW✓. Their advantage must be relevant to this example, so ignore references to reuse and separation. Not increased optimum temperature.	1
(iv)	Only glucose fits the <u>active site or active site</u> is correct shape to bind glucose/complementary shape to glucose or *vice versa*. AW✓	1
(b)(i)	Allow 1 mark for COOH and NH_2 version✓. Two marks for version with both COO^- and NH_3^+✓✓ .	2
(ii)	To remove/dissolve/hydrolyse protein stains (such as egg/blood). Accept good example alone but not simply 'stains'.	1 **Total 8**

Question	Expected answers	Marks
4. (a)	Two of the following: Disulphide bridge/ covalent✓ –S–S–✓ Must have – bond not …. Ionic ✓ $-COO^-$ $^+H_3N-$ ✓ van der Waals/instantaneous dipole–induced dipole✓ Diagram✓ should show two non-polar groups with/without dotted attraction – the CH_2 in glycine would be acceptable. $-CH_2-\ldots -CH_2-$ or $-CH_2-\ldots -CH_2-$	4
(b)	Quaternary✓	1
(c)	• 1. Increased pH increases $[OH^-]$ or decreases $[H^+]$. Accept amount.✓ • 2. converts $-NH_3^+$ to $-NH_2$✓. Accept removal of charge/ hydrogen ion etc from H^+.✓ • 3. This reduces ionic attractions/bonding ✓ (in tertiary structure). • 4. This changes shape of enzyme//tertiary structure reducing activity✓ Not active site alone. If they use COOH becoming COO^- they lose point 2. but max of three marks . Point 3 should then be an increase or change in ionic attractions/bonding by ecf. AW throughout	4
(d) (i)	Their curve should show lower rate at low [S], increasing at high [S] but not getting back to original V_{max}✓. Must show some levelling off.	1
(ii)	The inhibitor binds to the enzyme away from the active site✓, changing the (tertiary structure and) shape of <u>active site/ES complex</u>✓ , reducing rate.	2
		Total 12

Question	Expected answers	Marks
5.(a)	In writing or on their diagram find four marks from • 1. The condensation involves loss of water (between ribose and phosphate). This may be shown as H_2O in appropriate place in their diagram. Do not award mark if it refers to disaccharide formation.✓ • 2. Idea of a sugar-phosphate backbone.✓ This can be for P–S–P or S–P–S as a minimum. • Correct positions for attachment of phosphates to deoxyribose either by numbering 3,5 or on diagram of nucleotide structure.✓ If the numbers and diagram do not match give the mark if correct in the diagram. Simple furan version OK if C5 is clearly shown but not cyclopentane • Base attached to correct carbon on deoxyribose✓. (Either number 1 or diagram. If the number and diagram do not match give the mark if correct in the diagram). Accept simple furan. Accept simple cyclopentane version as long as the sidechain C is visible. QWC for at least two sentences that show legible text with accurate spelling, punctuation and grammar so that the meaning is clear.✓  	4 1
(b)	Deoxyribose instead of ribose.✓ The position is not required, but if given must be correct. Accept one more O in RNA sugar/ one less O in DNA sugar. Not reference to double/single strands.	1

Question	Expected answers	Marks
5 (c) (i)	As shown in diagram.✓ Any line for the link. 	1
(ii)	Two of following three points:✓✓ • 1. they allow double helix to unwind/m-RNA to dissociate from DNA strand ✓AW • 2.Accuracy of base pairing relies on different number of hydrogen bonds between base pairs (and similar size of the base pairs)✓ They are not expected to know how many hydrogen bonds in each case. AW • 3. Example of one base pair from CG GC AU UA TA AT. ✓	2
	Total	**9**

Mark Scheme 2815/03
June 2007

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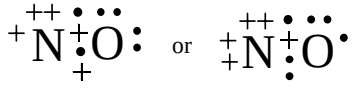
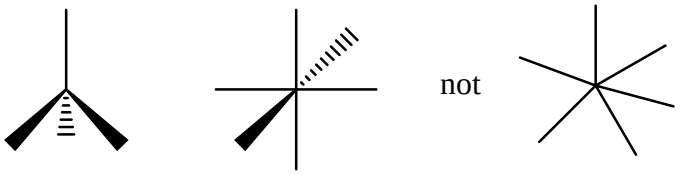
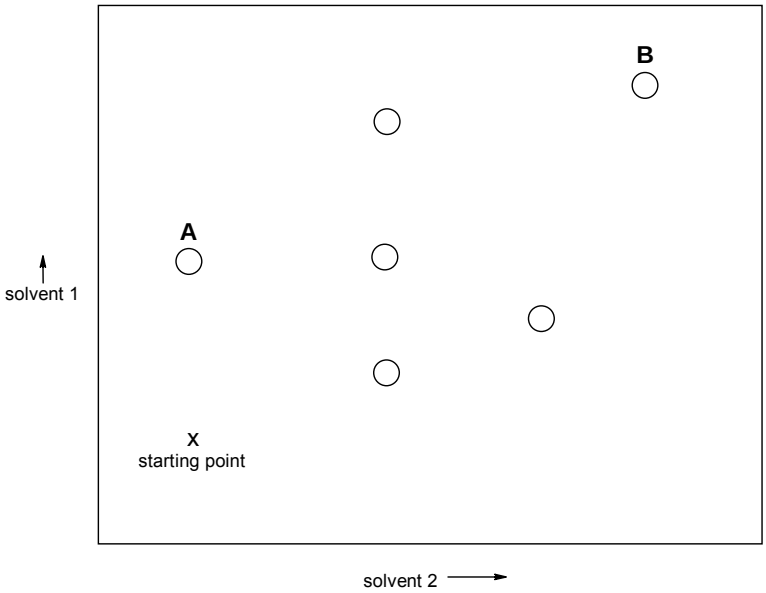
Question	**Expected answers**	**Marks**
1.(a)	Increased use of plastics for packaging.✓ AW	1
(b)(i)	Paper and card, plastics, textiles, organic waste. Any three.✓	1
(ii)	Reduces bulk of waste going into landfill✓. Heat can be used to heat local housing/generate electricity✓.	2
(iii)	Too low a temperature ✓ results in formation of dioxins/toxins ✓ from PVC/organochlorine compounds in the waste✓. Any two marks.	2
(c)(i)	Dissolved oxygen is needed by aquatic organisms for respiration✓.	1
(ii)	It allows aerobic decay of organic matter, or decay with oxygen / minimises formation of hydrogen/methane ✓.AW	1
	Total	**8**

2. (a)(i)	CO: incomplete combustion of hydrocarbons✓. Accept equation with hexane or higher alkane, but not with methane or carbon. NO: direct combination of the elements at temperature of engine✓. Accept balanced equation. Formulae or equations, if given, must be correct or CON. Equations alone will not do.	2
(ii)	 or . ✓	1
(b)(i)	Region between 15–20, and 50–70 km up✓. Allow the mark for second layer up/layer above troposphere AW.	1
(ii)	Absorbs UV radiation✓ which causes sunburn/skin cancers✓. Accept 'cancers'.	2
(iii)	Formation: $O_2 \rightarrow 2O$ $O_2 + O \rightarrow O_3$ Both equations needed for first mark✓. Need for hf/UV radiation/sunlight✓.(free standing mark) Excited atoms do not have to be indicated. Reference to equilibria not needed.	2
(iv)	NO reacts with ozone to form nitrogen dioxide and oxygen or equation $NO + O_3 \rightarrow NO_2 + O_2$ ✓ NO reacts with oxygen to form nitrogen dioxide or equation $2NO + O_2 \rightarrow 2NO_2$ ✓	2
(c) (i)	Any four of the following. • 1. Use of UV radiation✓ • 2. At least two radicals shown✓ • 3. NO oxidised to NO_2/equation✓(unless credited above) • 4. NO_2 converted to NO and O atoms/equation✓ • 5. O atoms combine with O_2 to form O_3/equation✓(unless credited above) • 6. Further reactions lead to aldehydes/ PAN ✓ • 7. mention of hydroxyl/hydrocarbon radicals✓. Other relevant and correct equation	4
(ii)	Concentration of substance/ rate of removal.✓. Or the <u>average</u> time a species spends in the atmosphere✓.	1
	Total	**15**

3. (a) (i)	Clearly silicate ✓ Clearly aluminate✓  Correct terms for the shapes are not necessary for the marks. Accept clear geometric solids without atoms.	2
(ii)	Silicate/aluminate/silicate sandwich ✓	1
(b)	• 1:1 clays have hydrogen bonding between layers ✓ • Using OH from aluminate and O from silicate✓ which prevents entry of water. • 2:1 clays have van der Waals/ no hydrogen bonding between layers ✓ • Water can enter easily, hydrogen bonding to the silicate O✓. • 2:1 clays can expand as they absorb water✓. AW	5
	QWC mark is for at least two sentences that show legible text with accurate spelling, punctuation and grammar so that the meaning is clear.	1
(c)	ClayK(s) + $H_2O(l)$ ⇌ ClayH(s) + $K^+(aq)$ + $OH^-(aq)$ For this or similar equation or for statement that K^+ is attracted to anions/negative charge on the clay.✓. When K^+ (aq) is removed by plant, either equilibrium moves to right to replace it or ion exchange can replace it ✓.	2
	Total	**11**

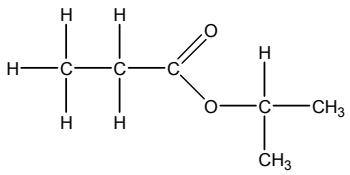
4. (a)(i)	Low temperature ✓ Increased pressure✓	2
(ii)	Aqueous carbon dioxide contains carbonic acid/H_2CO_3 or equation $H_2O + CO_2 \rightleftharpoons H_2CO_3$ ✓	
	Dissociation : $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ Or acids produce $H^+(aq)$ in water✓. Accept $H_2O + CO_2(aq) \rightleftharpoons HCO_3^- + H^+(aq)$ for the second mark	2
(b) (i)	Calcium carbonate reacts with aqueous/dissolved carbon dioxide ✓ forming $Ca(HCO_3)_2$ <u>solution</u>.✓	
	Equation $CaCO_3(s) + H_2O(l) + CO_{2(g/aq)} \rightleftharpoons Ca(HCO_3)_2(aq)$ The equation with all state symbols can earn both marks. Without state symbols it earns only the first mark above.	2
(ii)	Calcium hydrogencarbonate/formula decomposes ✓ to form <u>solid/insoluble</u> calcium carbonate/formula✓.	2
	The first mark can come from the equation. $Ca(HCO_3)_2 \rightleftharpoons CaCO_3 + H_2O + CO_2$ The first mark can also be earned by stating that the evaporation of CO_2 will pull the above equilibrium to the right.	
(c)	Sulphur dioxide dissolves in water to give sulphurous acid or $SO_2 + H_2O \rightleftharpoons H_2SO_3$✓. Oxidation of H_2SO_3 produces sulphuric acid or $2H_2SO_3 + O_2 \rightarrow H_2SO_4$ ✓ Allow both steps done in one equation for 2 marks. This dissociates to form sulphate ions✓ or equation.. Allow approach via sulphur trioxide. AW throughout but must be one equation altogether.	3
	Total	**11**

Mark Scheme 2815/04
June 2007

Question		Expected answers	Marks
1)	(a) (i)	Distribution of solute between stationary and mobile phases.✓	[1]
	(ii)	Mobile phase = carrier/inert gas (Allow named inert gas)✓ Stationary phase = (non-volatile) solvent (on solid support). ✓	[2]
b)	(i) & (iii)	 **Fig. 1.1** ✓✓	[2]
	(ii)	4✓ (only 4 amino acids are separated – the 5th is a mixture of 2 amino acids)	[1]
	(iv)	*6*✓	[1]
c)		Quantitative data/amount/% of each amino acid/ ✓ allow retention time/ allow could be attached to mass spectrometer to determine M_r values	[1]
d)		Electrophoresis involves movement of ions in an electric field/ use of voltage/potential difference ✓ NOT electric current separates by mass/size✓ separates by charge✓ pH control is essential because charge on the amino acid ion changes with a change in pH / e.g.of protonation/deprotonation✓ pH controlled by use of a buffer✓ QWC for two sentences linked together that clearly explain the process with correct spelling, punctuation and grammar. ✓	[5] [1]

Question	Expected answers	Marks
2a) (i)	$^{79}BrCH_2CH_2{}^{79}Br^+$ / $C_2H_4{}^{79}Br_2{}^+$✓ (if + is missing penalize only once on paper)	[1]
(ii)	$^{79}BrCH_2CH_2{}^{81}Br^+$ / $C_2H_4{}^{79}Br{}^{81}Br^+$✓	[1]
(iii)	$CH_2CH_2{}^{81}Br^+$ / $C_2H_4{}^{81}Br^+$✓	[1]
(b)	^{79}Br and ^{81}Br are in 1 :1 ratio ✓	[1]
(c)	Makes use of the equation n = <u>height of (m+1) peak x 100</u> height of m peak x 1.1 ✓ recognizes and uses n = 2 ✓ height of (m+1) peak = (2 x 8.8 x 1.1)/100 = 0.19/ 0.2 ✓	[3]
(d)	Any matching two from: *m*/*e* = 15 caused by $CH_3{}^+$ *m*/*e* = 171 caused by $CH^{79}Br^{79}Br^+$ *m*/*e* = 173 caused by $CH^{79}Br^{81}Br^+$ *m*/*e* = 175 caused by $CH^{81}Br^{81}Br^+$ ✓✓ ✓✓	[4]

Question		Expected answers	Marks
3a)	**(i)**	Electron **falling** from high energy to low energy. ✓ energy difference released (as electromagnetic radiation) ✓	**[2]**
	(ii)	Each series corresponds to the lower energy level to which excited electrons **falls**. ✓	**[1]**
	(iii)	The lines converge because the energy levels get closer together/at convergence the energy levels are continuous. ✓	**[1]**
	(iv)	(uses $E/h = f$) $f = 6.18 \times 10^{14}$ (s^{-1}) ✓ (uses $c/f = \lambda$) $\lambda = 4.85 \times 10^{-7}$ (m) ✓ *(uses h x c/E = λ) λ = 4.85 x 10^{-7}) (m) scores both* ✓✓ converts to nm by multiplying by 1 x10^9 to give 485 (nm) ✓	**[3]**
b)		carotene has chromophore**s**/π-bonds which can conjugate/has conjugation ✓ by conjugation/delocalisation moves to lower energy/narrows energy gap✓ therefore **<u>absorbs</u>** light in visible region hence is coloured✓	**[3]**

Question	Expected answers	Marks
4	**Infra red** - any two from absorption at approx 1700/between 1680–1750 cm^{-1} shows C=O ✓ absorption at approx 1200/between 1000–1300 cm^{-1} shows C–O ✓ no broad absorption at approx 3000 cm^{-1} therefore not O–H / or quotes either range 2500–3500 therefore not carboxylic acid / 3230–3550 therefore not alcohol ✓ ***3 max = 2***	**[2]** 2 marks for IR
	Mass spec M_r = 116 ✓ 116 – 32 (for the two oxygens) = 84 , hence a max of 6 Cs ✓ therefore **Molecular formula** is $C_6H_{12}O_2$✓ base peak = 57 = $CH_3CH_2C{=}O^+$/ or other correct fragment ion ✓ **n.m.r.** peak areas show that there are 12 Hs/ table shows there are 4 different H/proton environments ✓ δ = 0.9 (likely to be a) CH_3 next to a CH_2 (as it is split into a triplet)✓ δ = 1.2 (likely to be a) 2 x CH_3 next to a CH (as it is split into a doublet)✓ δ = 2.3 (likely to be a) CH_2 next to a CH_3 (as it is split into a quartet)/ CH_2 must be next to a C=O (δ = 2.0 – 2.9) ✓ δ = 4.1 (likely to be a) CH next to **two** CH_3 s / CH is next to an O (δ = 3.3 - 4.3) ✓ ***9 max = 7*** Compound **X** is  ✓***essential mark***	**[8]**

Mark Scheme 2815/05
June 2007

Question	Accepted answers	Marks
1 a) i)	The v.p. of a solvent in a solution is equal to the v.p. of the pure solvent multiplied by its mole fraction in the solution. / $P_A = N_A \times P^o_A$ with terms defined	[1]
(ii)	mol heptane = 100/100 = 1 mol octane = 19/114 = 0.167 (1) mol fraction heptane = 1/1.166 = 0.857 mol fraction octane = 0.166/1.166 = 0.143 (1) *P*(heptane) = 473 x 0.857 = 405.4 Pa *P*(octane) = 140 x 0.143 = 20.02 Pa (1) Total v.p. = 425.32 Pa / 425 Pa (1)	[4]
(b)	Column with beads (1) Condenser, water in at bottom out at top (1) A complete apparatus including flask, heating, thermometer, collection of distillate with no gaps (1)	[3]
(c) (i)	The intermolecular bonds between molecules of trichloromethane and between molecules of ethoxyethane are van der Waals forces/ permanent dipoles. (1) These are stronger in the mixture than the (dipole–dipole) attractions between the individual liquids. (1) This means that molecules in the mixture have less tendency to escape into the vapour phase than in the pure liquids. (1) Accept hydrogen bonding. Mark **(i)** and **(ii)** independently	[3]
(c) (ii)	Negative Deviation	[1]
(d) (i)	The azeotrope / azeotropic mixture	[1]
(d) (ii)	Use of tie lines on diagram from 20% upwards (1) 4 Plates (1)	[2]
		[Total: 15]

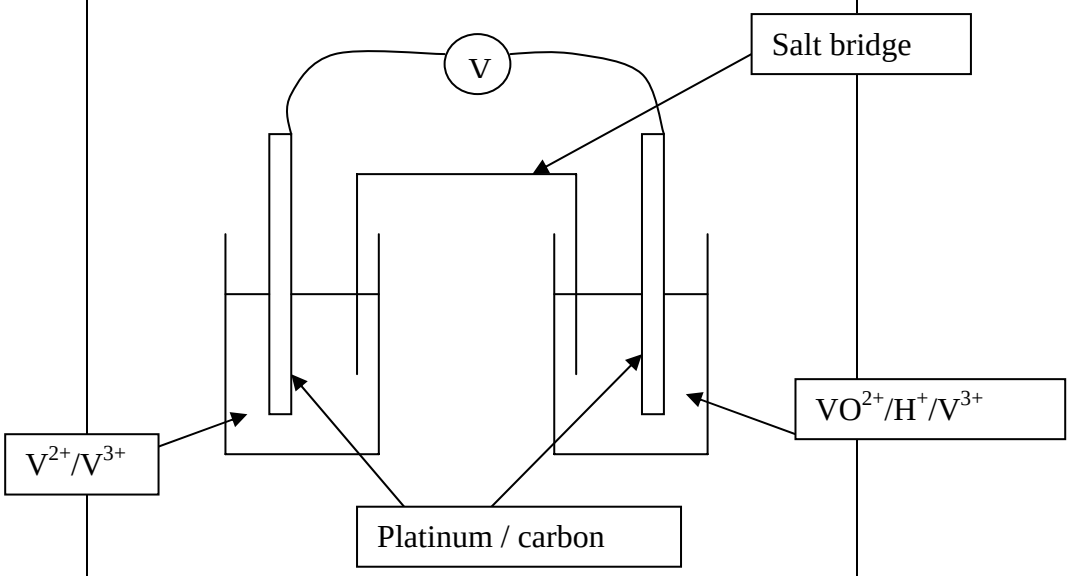
Question	Accepted answers		Marks
2 (a)	At low pressure Therefore particles have negligible volume At high temperature Therefore there are no intermolecular forces.	(1) (1) (1) (1)	[4]
(b) (i)	$PV = nRT$		[1]
(b) (ii)	$M_r = \frac{mRT}{PV}$ (1) $= \frac{0.174 \times 8.31 \times 343}{101000 \times 63 \times 10^{-6}}$ $M_r = 78$ (77.9)	(1) (1)	[3] **[Total: 8]**

Question	Accepted answers	Marks
3 (a)	Shape of graph to form a 'v' (1) areas correctly labelled: Solution (1) Ice and solution (1) Salt and solution (1) Temperature at 0°C and –21°C (1) Eutectic composition at 29% NaCl (1)	[6]
(a) (ii)	At –5°C, a concentration of 14% ± 4% causes ice to be in equilibrium with the solution [mark this according to their sketch in (i)] (1) Increasing concentration causes NaCl and water all to be in solution and so no ice is present. (1) Use of diagram can score both marks. An alternative method may be to draw a line at 20% and say that this is in solution at –5°C	[2]
(b)	From Graph, at 70 °C, 120 g is dissolved At 25 °C , 42 g is dissolved (1) So, 120 – 42 = **78 g** precipitated (+ or – 2 g) (1)	[2] **[Total: 10]**

Question	Accepted answers	Marks
4 (a)	Penicillin and water added to ethoxyethane in a separating funnel and shaken (1) Allow layers to separate and run off bottom layer/water (1) It works because the 2 layers are immiscible (1) The solute/organic compound dissolves to different extents in different solvents. (1) QWC for logical sequence describing a process that will work using correct terms in context.	[4] [1]
(b) (i)	This is the equilibrium constant of the concentration of the solute in 2 immiscible solvents at equilibrium (1)	[1]
(b) (ii)	$K = 5/1 = \frac{\text{[conc. in alcohol]}}{\text{[conc. in water]}}$ $\frac{m/50 \times 1000}{0.1 - m/100 \times 1000} = 5$ (1) So $20m = 5(1 - 10m)$ (1) $70m = 5$ (1) $m = 0.0714$ mol so to 3 sig figs amount = **0.071 mol** (1) Can award 3 sig figs mark on any ecf answer	4 max [3]
(b) (iii)	Repeated distribution(s) (1) using smaller portions (1) Consequential additions to the aqueous layer (each time fresh) (1)	[3] **[Total: 12]**

Mark Scheme 2815/06
June 2007

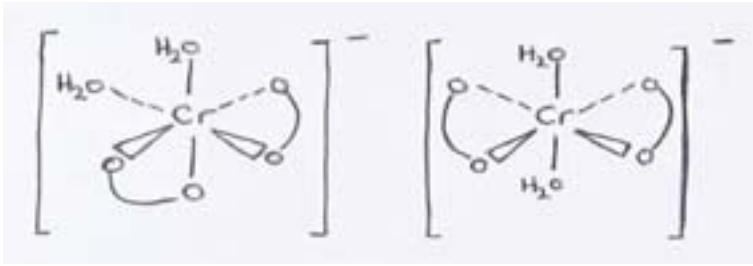
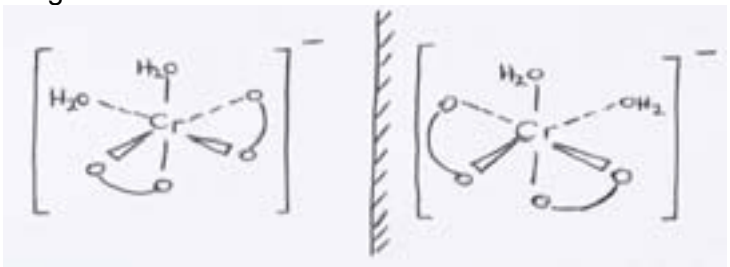
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument	
Question	**Expected answers**	**Marks**
1 (a)	(White) paint, (whitener in) toothpaste, cosmetics, food colours, sunscreen, crayons, pigment (not dye)	1
(b) (i)	Ti^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$	1
(ii)	Incomplete d-subshell electrons absorb (some wavelengths of visible) light	1 1
(iii)	Purple / violet-red / red-purple/Magenta (not violet) Peak absorbance is green (accept blue-green or geen-yellow) / transmits violet and red	1 1
(iv)	Goes colourless / forms a white solid Loses its d-electron / Ti^{4+} has no d-electron	1 1
(c)	Ligands cause a splitting of d-orbitals Different ligands produce a different energy gap (resulting in a different wavelength of visible light being absorbed).	1 1
(d)	K_2TiO_3 / $K_2[Ti(OH)_6]$ / K_4TiO_4 / $KHTiO_3$ or any other formula matching the rules of oxidation numbers	1
		Total: 11

Question	Expected answers	Marks
2 (a)	VO_2^+	1
(b) (i)	B and D	1
(ii)	 Allow ecf from (b) (i) Solutions can be reversed.	4

Question	Expected answers	Marks
(iii)	298 K / 25 ^{o}C temperature all solutions 1 mol dm^{-3} Both needed for 1 mark. Ignore any reference to pressure	1
(c) (i)	$Zn + 2V^{3+} \rightarrow Zn^{2+} + 2V^{2+}$ Correct species Equation balanced	1 1
(ii)	Green to violet / lilac / mauve / purple / magenta	1
(iii)	Zinc dissolves / disappears / bubbles	1
(d)	20 cm^3 of 0.100 mol dm^{-3} VO^{2+} = 0.002 moles 0.002 moles VO^{2+} = 0.0004 moles MnO_4^- 0.0004 moles MnO_4^- are in 16.0 cm^3	1 1 1
		Total: 14

Question	Expected answers	Marks
3 (a) (i)	Pink to blue	1
(ii)	$[Co(H_2O)_6]^{2+}$ – octahedral	1
	$[CoCl_4]^{2-}$ – tetrahedral	1
(b) (i)	$2[Co(H_2O)_6]^{3+} + 2I^- \rightarrow 2[Co(H_2O)_6]^{2+} + I_2$	1
(ii)	I_2 is a stronger oxidising agent than $[Co(NH_3)_6]^{3+}$ / I^- gains electrons more easily Accept calculation of cell potential and non feasibility argument	1
(iii)	$[Co(NH_3)_6]^{3+}$ is more stable	1
	the $E^{\ominus}$ value is less positive so the forward reaction is less likely to occur / ammonia is a stronger ligand / ammonia forms stronger dative bonds	1
		Total: 7

Question	Expected answers	Marks
4 (a)	Ligand able to donate two lone pairs to form dative covalent / co-ordinate bonds	1 1
(b)	 	
	3-D diagram with three ethanedioate ligands used correct bonding between ligands and Cr^{3+} correct charge on ion (3–) (Accept O—O as minimum for ethanedioate ion)	1 1 1
(c)	stereoisomers have same <u>structural</u> formula but a <u>different arrangement in space</u>	1

Question	Expected answers	Marks
5	 Diagrams of *cis* and *trans* isomers	2
	 Diagrams showing two optical isomers (If diagrams are wrong / not used give 1 mark for mention of *cis*/*trans* and optical isomerism)	2
	H_2O at 90°/ adjacent in *cis* / 180° / opposite in *trans* (not from diagram)	1
	Optical isomers are non-superimposable mirror images	1
	Quality of Written Communication: At least three of the following key words used in context: non-superimposable, mirror images, optical, *cis*/*trans*, geometric, plane polarised, rotate, chiral, asymmetric	1
		Total: 13

Mark Scheme 2816/01
June 2007

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

   x = incorrect response (errors may also be underlined)
   ^ = omission mark
   bod = benefit of the doubt (where professional judgement has been used)
   ecf = error carried forward (in consequential marking)
   con = contradiction (in cases where candidates contradict themselves in the same response)
   sf = error in the number of significant figures

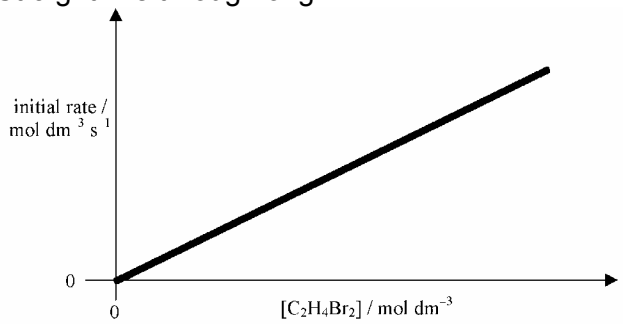
4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

   Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

7. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument	
Question	**Expected answers**	**Marks**
1 (a) (i)	Curve downwards starting at $t = 0$ ✓ with slope gradually levelling off with no increase ✓ (don't worry about hitting the x axis)	**[2]**
(ii)	Tangent shown at start ✓	**[1]**
(iii)	Half-life is constant OR: draw tangents and then plot a 2nd graph of tangent or rate against concentration, which is a straight line through the origin. ✓	**[1]**
(iv)	Straight line through origin ✓  	**[1]**
(b)	4 times [KI], rate increases by 4 ✓, so order = 1 with respect to KI ✓ independent marks	**[2]**
(c) (i)	rate/r = k[$C_2H_4Br_2$] [KI] ✓ or ecf from **(b)**	**[1]**
(ii)	$k = \frac{\text{rate}}{[C_2H_4Br_2]\,[KI]} / \frac{0.027}{0.50 \times 0.18}$ ✓ = 0.3(0) ✓ units: $dm^3\ mol^{-1}\ s^{-1}$ ✓ units dependent on rate equation in **(i)**. Mark independently.	**[3]**
		Total: 11

Question	Expected answers	Marks
2 (a)	$CH_4 + H_2O \longrightarrow 3H_2 + CO$ $CH_4 + 2H_2O \longrightarrow 4H_2 + CO_2$ $CH_4 + H_2O \longrightarrow 2H_2 + CH_2O$/HCHO $CH_4 + 2H_2O \longrightarrow 2H_2 + CH_2O_2$/HCOOH ✓ or $CH_4 + H_2O \longrightarrow H_2 + CH_3OH$ ✓	[1]
(b) (i)	$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$ ✓ $[NH_3]^2 = (K_c \times [N_2] \times [H_2]^3)$ ✓	[1]
(ii)	= 0.768 ✓ $[NH_3] = \sqrt{0.78} = 0.876/0.88$ (mol dm^{-3})✓ If no powers, then rearrangement mark only.	[3]
(c)	**High pressure**: **adv:** Fewer moles on r.h.s. → equilibrium moves to right ✓ Greater pressure → faster rate/more frequent collisions ✓ **dis:** Safety issues from (high) pressure / Expense of (high) pressure ✓	[3]
	High temperature: **adv:** more collisions exceed activation energy/ more successful collisions/more energetic collisions/molecules have more energy ✓ **dis:** Equilibrium moves to left/reverse direction because (forward) reaction is exothermic ✓	[2]
	Catalyst: lowers activation energy/ allows reaction to take place at a lower temperature ✓	[1]
	QWC: Uses 2 words following list in the correct context: exothermic/endothermic, activation energy, collisions, equilibrium/Le Chatelier	[1]

(d)	Moles **NH_3** required = $\frac{1.3 \times 10^{12}}{17}$ = 7.6×10^{10} mol ✓ calc: 7.6470588×10^{10} mol Volume **CH_4 = *n*(NH_3) x 10.5** $7.6 \times 10^{10} \times \frac{7}{16} \times 24 = 8.0 \times 10^{11}$ dm^3✓ ***n*(NH_3) x 10.5** calc: $8.029411765 \times 10^{11}$ dm^3 Volume **air = *n*(NH_3) x 15** $7.6 \times 10^{10} \times \frac{(8+2)}{16} \times 24 = 1.1 \times 10^{12}$ dm^3✓ OR 0.228×10^{12} dm^3 O_2 **and** 0.912×10^{12} dm^3 N_2 calc: $1.147058824 \times 10^{12}$ dm^3 OR $0.229411764 \times 10^{12}$ dm^3 O_2 **and** $0.917647059 \times 10^{12}$ dm^3 N_2 Volume **H_2O = *n*(NH_3) x 11.25** $7.6 \times 10^{10} \times \frac{10}{16} \times 18 = 8.6 \times 10^{11}$ cm^3✓ calc: $8.60294117 \times 10^{11}$ cm^3/ 8.60294117×10^{8} dm^3	**[4]**
		Total: 16

Question	Expected answers	Marks
3 (a) (i)	proton donor ✓ partially dissociates ✓	 [2]
(b)	$K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$ / $\frac{[H^+]^2}{[HCOOH]}$ / $[H^+] = \sqrt{(K_a \times [HA])}$ / $1.58 \times 10^{-4} = \frac{[H^+]^2}{0.025}$ / ✓ $[H^+] = \sqrt{\{(1.58 \times 10^{-4}) \times (0.025)\}} = 1.99 \times 10^{-3}$ mol dm^{-3} ✓ $pH = -\log[H^+] = -\log 1.99 \times 10^{-3} = 2.70$ ✓ 5.4034 (no square root) **with working** would score 1 mark.	[3]
(c) (i)	A solution that minimises pH changes/resists pH changes/opposes pH changes ✓ (**not** pH is kept constant/pH maintained/pH cancelled out.	[1]
(ii)	HCOONa/$HCOO^-$/ NaOH ✓ $HCOO^-$ is the conjugate base/ HCOONa is the salt of the weak acid or HCOOH/ HCOONa supplies $HCOO^-$ ✓	[2]
(iii)	*Two points from:* K_a /pK_a /acid strength/amount of dissociation ✓ temperature ✓ (but **not** "temperature & pressure") ratio/amounts/concentrations of weak acid and **conjugate** base/**salt** ✓ (or reverse ratio) (**not** ……. concentration of base as it could imply NaOH)	[2 max]
(d)	Mass of $HNO_3 = \frac{1400 \times 65}{100}$ / 910 g ✓ Moles of $HNO_3 = \frac{910}{63} = 14.4$ ✓ $pH = -\log[H^+] = -\log 14.4 = -1.16/1.2$ ✓ calc –1.15836 pH from ignoring 65% pH = –1.35: **with working**, 2 marks.	[3]
(e)	$\longrightarrow$ ……. $CO_2 + H_2O$ ✓ Complete correct balanced equation for 2nd mark: $2HNO_3 + CaCO_3 \longrightarrow Ca(NO_3)_2 + CO_2 + H_2O$ / $2H^+ + CaCO_3 \longrightarrow Ca^{2+} + CO_2 + H_2O$ / $2H^+ + CO_3^{2-} \longrightarrow CO_2 + H_2O$ ✓	[2]
(f)	Two species differing by H^+ …. AW✓ one pair: HNO_3 and NO_3^- ✓ other pair: $HCOOH$ and $HCOOH_2^+$ ✓	[3]

(g) (i)	$6HNO_3 + S \longrightarrow H_2SO_4 + 6NO_2 + 2H_2O$/ $4HNO_3 + S \longrightarrow H_2SO_4 + 4NO_2 + H_2$/ $2HNO_3 + S \longrightarrow H_2SO_4 + NO_2 + \frac{1}{2}N_2$✓	**[1]**
(ii)	from (+)5 to (+)4 ✓	**[1]**
		Total: 20

Question	Expected answers	Marks
4 (a)	M(AgCl) = 143.5 g mol^{-1} ✓ Mass of Cl in AgCl = $\frac{35.5 \times 0.610}{143.5}$ / 0.151 g ✓ Mass of Fe in compound = 0.270 – 0.151 = 0.119 g ✓ Ratio Fe : Cl = $\frac{0.119}{55.8}$: $\frac{0.151}{35.5}$ / 2.13 x 10^{-3} ✓ : 4.25 x 10^{-3} ✓ Ratio = 1 : 2; Formula = $FeCl_2$ ✓ OR: M(AgCl) = 143.5 g mol^{-1} ✓ n(AgCl) = $\frac{0.610}{143.5}$ = 4.25 x 10^{-3} mol ✓ n(Cl) = 4.25 x 10^{-3} mol Mass of Cl = 4.25 x 10^{-3} x 35.5 = 0.151 g ✓ Mass of Fe in compound = 0.270 – 0.151 = 0.119 g ✓ Ratio Fe : Cl = $\frac{0.119}{55.8}$: 4.25 x 10^{-3} = 2.13 x 10^{-3} ✓: 4.25 x 10^{-3} Ratio = 1 : 2; Formula = $FeCl_2$ ✓	**[6]**

Question	Expected answers	Marks
4 (b)	moles of NaOH = $\frac{0.1263 \times 23.75}{1000}$ / 3.00×10^{-3} mol ✓ moles of acid = 3.00×10^{-3} mol ✓ moles of acid in flask = $10 \times 3.00 \times 10^{-3} = 3.00 \times 10^{-2}$ mol ✓ molar mass of compound = $\frac{\text{mass}}{n} = \frac{2.58}{3.00 \times 10^{-2}} = 86$ ✓ Molecular formula = $C_4H_6O_2$ ✓ A 4 carbon carboxylic acid (*e.g*. butanoic acid) shown (bod) ✓ Any 2 possible isomers ✓✓ from: $CH_2=C(CH_3)COOH$ $CH_2=CHCH_2COOH$ *cis* $CH_3CH=CHCOOH$ *trans* $CH_3CH=CHCOOH$ Accept structural formulae that are unambiguous.	**[4]** **[4]**
		Total: 13 max

Mark Scheme 2816/03
June 2007

PLAN Skill P **16 marks maximum** (out of 19 available)

Titration method (T) – 8 marks

Either a potassium manganate(VII) or an iodine-thiosulphate titration is suitable.
An unsuitable titrant forfeits all marks except T1 and T6

T1 Controlled dilution of hydrogen peroxide **[1]**
Use of (i) pipette (ii) volumetric flask and (iii) distilled water are required.

T2 Calculation ***and*** justification of suitable quantities for dilution **[1]**

T3 Transfer peroxide into conical flask using a pipette ***and*** acidify with H_2SO_4 **[1]**
*For the "iodine method" addition of excess KI is **also** needed*

T4 Use $KMnO_4$ of known/specified concentration in the burette **[1]**
Concentration of $KMnO_4$ must lie between 0.01 and 0.20 mol dm^{-3}
For "iodine method" use sodium thiosulphate (0.01 – 0.5 M) in the burette

T5 No indicator (implied) ***and*** end-point change is to pink/pale purple **[1]**
For "iodine method" use starch: goes colourless (not "clear")

T6 Obtain two consistent accurate/concordant titres (***or*** within 0.1 cm^3) **[1]**

T7 Equation(s) for titration ***or*** ionic equations **[1]**
$2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5O_2 + 8H_2O$
or $H_2O_2 + H_2SO_4 + 2KI \rightarrow 2H_2O + I_2 + K_2SO_4$ ***and*** $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$

T8 Specimen calculation of concentration of peroxide from titration data. **[1]**
Calculation must include "scaling up" to allow for dilution procedure

Order Determination (D) – 7 marks

D1 Realises need for preliminary work to obtain a measurable rate of reaction, by adjusting ***either*** the concentration of the H_2O_2 ***or*** the mass of catalyst. **[1]**

D2 Outline of how to start the procedure – both bullets needed **[1]**
- use known/specified volume of hydrogen peroxide
- start timing immediately when specified catalyst (MnO_2) is added

D3 Monitoring procedure – **one** of the following methods described briefly **[1]**

- Measure the quantity of oxygen at regular intervals using a gas syringe (or equivalent)
- Mass loss to determine mass of oxygen evolved at regular intervals
- A procedure that enables $[H_2O_2]$ to be determined at regular intervals.
- A procedure with a range of initial $[H_2O_2]$ concentrations, measuring the times taken for a small (< $20cm^3$) volume of gas (syringe measurement) to be produced
- Sampling technique
- (i) use of pipette to withdraw a sample

  (ii) quench the sample ***or*** remove catalyst [to stop reaction]

  (iii) suitable titrant for sample named

D4 Accuracy precautions: accept any **two** from the six below **[1]**

- Stir/swirl ***or*** mix reagents at start of reaction
- Use water bath to keep temperature of mixture constant during the reaction
- Repeat whole procedure ***and*** calculate mean values/ignore anomalies.
- Calculation of maximum volume of H_2O_2 to use so that syringe is not over-filled
- Use an ignition tube (or equivalent) to separate reagents if gas collection used

D5 Sketch graph of typical results showing quantity *v* time, with axes labelled **[1]**

- Volume (or mass) of oxygen increasing with time
- Concentration of hydrogen peroxide decreasing with time (**but** candidate must show how the concentration of peroxide was derived from the O_2 measurements)
- An "initial rate v concentration" graph, linear through 0,0 (assuming that the candidate did a series of experiments using varying concentrations of peroxides)

D6 Detailed explanation of how to analyse the data obtained **[1]**

D7 Brief statement as to how the order of reaction is shown to be first order **[1]**

- *Half-life: if any two half-lives are [nearly] equal, this indicates first order*
- *Initial rate compared with initial concentration is straight line/ directly proportional* ***or*** *if one doubles, the other doubles (or specimen figures quoted)*
- *Tangent-rate: Graph of rate v concentration is a straight line [through 0,0]*

S **4 marks for safety, sources and QWC**

S1 **Risk assessment** for hydrogen peroxide in the procedure chosen **[1]**
"20 volume" is irritant (not corrosive)
Accept wearing specs ***or*** *gloves (provided linked to the hazard) as precaution.*

S2 **Two** different **sources** quoted in the text ***or*** at end of plan. **[1]**
Book references ***must*** *have chapter or page numbers*
Internet reference must go beyond the first slash of web address
Accept ***one*** *specific reference to "Hazcards", by name or number*

S3 **QWC**: text is legible ***and*** spelling, punctuation and grammar are accurate **[1]**
Award S3 if there are fewer than ***six*** *errors in spelling, punctuation or grammar.*
A repeated error (e.g. no capitals at start of sentences) is penalised once only.

S4 **QWC**: information is organised clearly and coherently **[1]**

- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language used correctly? (****One*** *error is allowed without penalty).*
- *Is the description in a reasonably logical order?*

Practical Test (Part B)

Page 3 (Part 1) – 9 marks

Both units at top of table ***and*** final temperature ***with*** unit given *(at foot of page)* **[1]**

Five readings for *t* recorded in table **[1]**

All five t **values show** increasing increments **of time** **[1]**

The time for V = 10.0 cm^3 is within **10% of the** supervisor's mean time **[2]**
*Award 2 marks if within 10%: award **one** mark if within 20%*
Use the mean of the supervisor's two readings to assess accuracy

The time for V = 20.0 cm^3 is **within** 20% of the **supervisor's time** **[1]**

Candidate's self-consistency marks:

Divide candidate's time at V = 10 by the time at V = 5
Give **one** mark if the answer is between 2.00 and 2.20 (incl) **[1]**

Divide candidate's time at V = 15 by the time at V = 5
Give **one** mark if the answer is between 3.30 and 3.55 (incl) **[1]**

Divide candidate's time at V = 25 by the time at V = 10
Give one mark if the answer is between 3.10 and 3.55 (incl) **[1]**

Part 2 – 21 marks maximum *(22 available)*

Page 5 – 3 marks

2 (a) $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$ **[1]**

***n*(I_2) produced in experiment = *n*(H_2O_2) = 0.000417 mol (4.17 x 10^{-4})** **[1]**
The number of moles of iodine must be specifically shown in the working.
If the moles link is via KI (or iodide), award 0 out of 2 for calculation
n(thiosulphate) required in experiment = 2 x 0.000417 mol **[1]**
***so* volume of thiosulphate required in experiment**
= $^{0.000833}/_{0.015}$ = 0.0555(5) dm^3

Page 6 – 2 marks

2 (b) Second column of table correctly completed with '35.6'
and missing log value inserted = 0.194 **[1]**

All times correctly entered in the table in seconds **[1]**

Page 7 – 6 marks for graph

2(c) Both graph axes labelled, with numbering and units of time (s) shown **[1]**

Sensible uniform scales chosen for each axis, starting from 0,0 **[1]**
*Points **plotted** must extend for at least half of the grid, in each direction*
Non-uniform scales (check the log axis) forfeit the previous mark also.

Four points plotted correctly **[2]**

Points must be within half a small square each way *and* on the right side of grid lines
Two points wrong = 0

Best fit straight line drawn **[2]**
One mark is awarded for a reasonable attempt.

Page 8 – 9 marks available *(but 8 on question paper)*

(d) 1 mark

The points on the graph fit a straight line *or* quantities are 'directly proportional' **[1]**

(e) 4 marks

Construction to determine the gradient is clearly indicated on graph **[1]**
NB: *Construction **must** include at least **four** large squares in one direction*
Correct method of calculating gradient = $^{\text{change in log}}/_{\text{change in t}}$ **[1]**

Rate constant correctly calculated (k = 2.3 x gradient) **[1]**
***k** will be approximately 1.0 x 10^{-3} s^{-1} (answer expressed to 2 or 3 sig fig)*
Unit is s^{-1} **[1]**

(f) 4 marks can be awarded *(but 3 on question paper)*

First order with respect to hydrogen peroxide **[1]**

KI and H_2SO_4 are in [large] excess … **[1]**

….. so their concentrations are [nearly] constant **[1]**

Either sodium thiosulphate is not a reagent in the reaction under investigation
or [H_2O_2] is the only reagent whose concentration changes **[1]**

Page 9 – 2 marks (Safety)

(g) Add [aqueous] sodium thiosulphate to the stain **[1]**

Sodium thiosulphate is not harmful/has no hazard itself
or the iodide ions produced are not harmful **[1]**

Part 3: Skill E Maximum 14 marks (from 17 marking points)

Page 10 – 9 marks available

(a) 2 marks

% error = $^{0.04}/_{10}$ [x 100] **[1]**

0.4% **[1]**

(b) 4 marks available (but only 3 on question paper)

Each reading was only done once *or* whole experiment should be repeated **[1]**

Consistent results would be evidence of reliability **[1]**
'Taking averages means reliability' does not score this mark

Points on graph are close to best fit [giving evidence of reliability] **[1]**

One anomalous/residual result correctly identified **[1]**
or an appropriate statement that there aren't any residuals

(c) 3 marks available, maximum (but only 2 on question paper)
*Credit any **three** ideas*

Reaction would be faster ***or*** times measured would be shorter…… **[1]**

….. so there would be a greater error in measurement of times **[1]**

There would not be enough time between readings to add the "thio" and mix **[1]**

If the concentration was higher, the blue colour appeared much more suddenly **[1]**

If a greater concentration of H_2O_2 was used, the total volume of "thio" needed for complete reaction would be greater than 55.6 cm^3 **[1]**

Page 11 – 8 marks available

(d) 3 marks available, maximum (but only 2 on question paper)
*Credit any **three** ideas from the following four*

KI is in <u>excess</u> . . **[1]**

. . so it doesn't matter if its volume is not measured exactly **[1]**

It would take longer to add the aqueous KI to the mixture from a pipette
or a measuring cylinder allows aqueous KI to be poured in quickly **[1]**

Timer should be started <u>half way</u> through the addition [so would be less accurate]
or starting timer after the addition of all aq KI would give an error in $t = 0$ **[1]**

(e) **3 marks:** credit any **three** ideas from the following seven

Because the stop watch was still running, you wouldn't be able read it to 0.01 s
or you would have to stop the stop watch in order to read it [to 0.01 s] **[1]**

The times are long/well spread, so an error of one second is not significant
or % error is small because the times are large **[1]**

When graph was plotted, the scale is too small to show 0.01 s intervals
or times would have to be rounded up when graph was plotted **[1]**

The reagents were not measured to high level of accuracy, so there is no benefit in measuring the time to a high level of accuracy **[1]**

Human response times are finite **[1]**

The timer was started slightly after the reaction had begun/chemicals had been mixed [so all timings were slightly inaccurate] **[1]**

Blue colour does not appear instantaneously/ takes a second or so to develop **[1]**

(f) **2 marks** (from the ideas listed below)

Process the reading as $V = 26.0\ cm^3$ **[1]**

Plot time, t, and log $^{55.6}/_{55.6 - 26.0}$ on the graph **[1]**

OR Ignore final/26.0 cm^3 reading when plotting the graph
or realise that this is an anomalous reading **[1]**
Only one mark is available for this strand

Advanced GCE (Subject) (Aggregation Code(s))
January 2007 Assessment Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	47	41	35	29	24	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	48	41	34	28	22	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	95	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	95	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	89	78	68	58	48	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	69	61	53	46	39	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	68	60	53	46	39	0
	UMS	90	72	63	54	45	36	0
2815B	Raw	90	69	61	53	46	39	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	68	61	54	47	40	0
	UMS	90	72	63	54	45	36	0
2815D	Raw	90	68	60	52	44	36	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	69	61	53	46	39	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	97	87	77	67	58	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	97	87	77	67	58	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	91	80	70	60	50	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3882	300	240	210	180	150	120	0
7882	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3882	20.7	39.7	57.8	73.3	86.1	100	14835
7882	29.9	55.3	74.1	88.0	96.2	100	11113

For a description of how UMS marks are calculated see;
http://www.ocr.org.uk/exam_system/understand_ums.html

Statistics are correct at the time of publication

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

(General Qualifications)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553