UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/11 Paper 1 (Multiple Choice), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question Number	*Key*	*Question Number*	*Key*
1	**B**	21	**A**
2	**C**	22	**A**
3	**D**	23	**D**
4	**C**	24	**A**
5	**B**	25	**C**
6	**C**	26	**D**
7	**C**	27	**D**
8	**A**	28	**C**
9	**D**	29	**D**
10	**D**	30	**C**
11	**A**	31	**B**
12	**C**	32	**D**
13	**A**	33	**B**
14	**B**	34	**A**
15	**B**	35	**B**
16	**B**	36	**A**
17	**C**	37	**B**
18	**C**	38	**B**
19	**A**	39	**D**
20	**C**	40	**C**

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/12 Paper 1 (Multiple Choice), maximum raw mark 40

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International Examinations

Question Number	*Key*	*Question Number*	*Key*
1	**A**	21	**C**
2	**A**	22	**D**
3	**D**	23	**A**
4	**C**	24	**B**
5	**C**	25	**B**
6	**B**	26	**A**
7	**D**	27	**A**
8	**C**	28	**B**
9	**D**	29	**D**
10	**A**	30	**A/B***
11	**C**	31	**A**
12	**B**	32	**C**
13	**C**	33	**A**
14	**C**	34	**D**
15	**D**	35	**B**
16	**B**	36	**D**
17	**C**	37	**D**
18	**D**	38	**B**
19	**C**	39	**C**
20	**C**	40	**A**

*This question contained some ambiguity. As a result, in this exceptional circumstance, answers A and B were both credited.

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/13 Paper 1 (Multiple Choice), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question Number	*Key*	*Question Number*	*Key*
1	**C**	21	**D**
2	**D**	22	**A**
3	**B**	23	**A**
4	**B**	24	**A**
5	**C**	25	**C**
6	**C**	26	**C**
7	**C**	27	**D**
8	**D**	28	**D**
9	**A**	29	**C**
10	**A**	30	**D**
11	**C**	31	**B**
12	**D**	32	**B**
13	**A**	33	**B**
14	**B**	34	**D**
15	**B**	35	**A**
16	**C**	36	**A**
17	**B**	37	**C**
18	**C**	38	**D**
19	**A**	39	**B**
20	**C**	40	**B**

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/21 Paper 2 (AS Structured Questions), maximum raw mark 60

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UNIVERSITY of CAMBRIDGE
International Examinations

1 (a) (i) mass of C = $\frac{12 \times 0.352}{44}$ = 0.096g (1)

n(C) = $\frac{0.096}{12}$ = 0.008 (1)

(ii) mass of H = $\frac{2 \times 0.144}{18}$ = 0.016g (1)

n(H) = $\frac{0.016}{1}$ = 0.016 (1)

(iii) mass of oxygen = 0.240 – (0.096 + 0.016) = 0.128g (1)

n(O) = $\frac{0.128}{16}$ = 0.008 (1)

allow ecf at any stage [6]

(b) C : H : O = 0.008: 0.016 : 0.008 = 1:2:1

allow C : H : O = $\frac{0.096}{12}$: $\frac{0.016}{1}$: $\frac{0.128}{16}$ = 1:2:1

gives C H_2O (1) [1]

(c) (i) $M_r = \frac{mRT}{pV} = \frac{0.148 \times 8.31 \times 333}{1.01 \times 10^5 \times 67.7 \times 10^{-6}}$ (1)

= 59.89

allow 59.9 or 60 (1)

(ii) $C_2H_4O_2$ (1) [3]

(d) CH_3CO_2H (1)

HCO_2CH_3 (1) [2]

(e) the only products of the reaction are the two oxides H_2O and CO_2 and copper (1) [1]

[Total: 13]

2 **(a)** $S(g) \rightarrow S^{+}(g) + e$
correct equation (1)
correct state symbols (1) [2]

(b) **from Na to Ar**,
electrons are added to the same shell/have same shielding (1)
electrons are subject to increasing nuclear charge/proton number (1)
electrons are closer to the nucleus **or** atom gets smaller (1) [3]

(c) **(i)** **Mg and A*l***
in Mg outermost electron is in 3s **and**
in A*l* outermost electron is in 3p (1)

3p electron is at higher energy **or**
is further away from the nucleus **or**
is more shielded from the nucleus (1)

(ii) **S and P**
for S one 3p orbital has paired electrons **and**
for P 3p sub-shell is singly filled (1)

paired electrons repel (1) [4]

(d) **(i) and (ii)**

element	Na	Mg	A*l*	Si	P	S
conductivity	high	high	—	moderate	low	low
melting point	low	high	—	high	low	low
	(1)	(1)		(1)	(1)	(1)

one mark for each correct column [5]

(e) germanium/Ge (1) [1]

[Total: 15]

3 **(a)** the overall enthalpy change/energy change/ΔH for a reaction (1)

is independent of the route taken **or**
is independent of the number of steps involved
provided the initial and final conditions are the same (1) [2]

(b) **(i)** $K_2CO_3 + 2HCl \rightarrow 2KCl + H_2O + CO_2$ (1)

(ii) heat produced = m × c × δT = 30.0 × 4.18 × 5.2
= 652.08 J per 0.0200 mol of K_2CO_3 (1)

(iii) 0.020 mol $K_2CO_3 \equiv$ 652.08 J

1 mol $K_2CO_3 \equiv \frac{652.08 \times 1}{0.0200}$ = 32604 J

enthalpy change = –32.60 kJmol ^{1} (1)

(iv) to prevent the formation of $KHCO_3$ **or**
to ensure complete neutralisation (1) [4]

(c) **(i)** $KHCO_3 + HCl \rightarrow KCl + H_2O + CO_2$ (1)

(ii) heat absorbed = m × c × δT = 30.0 × 4.18 × 3.7
= 463.98 J per 0.0200 mol of $KHCO_3$ (1)

(iii) 0.020 mol $KHCO_3 \equiv$ 463.98 J

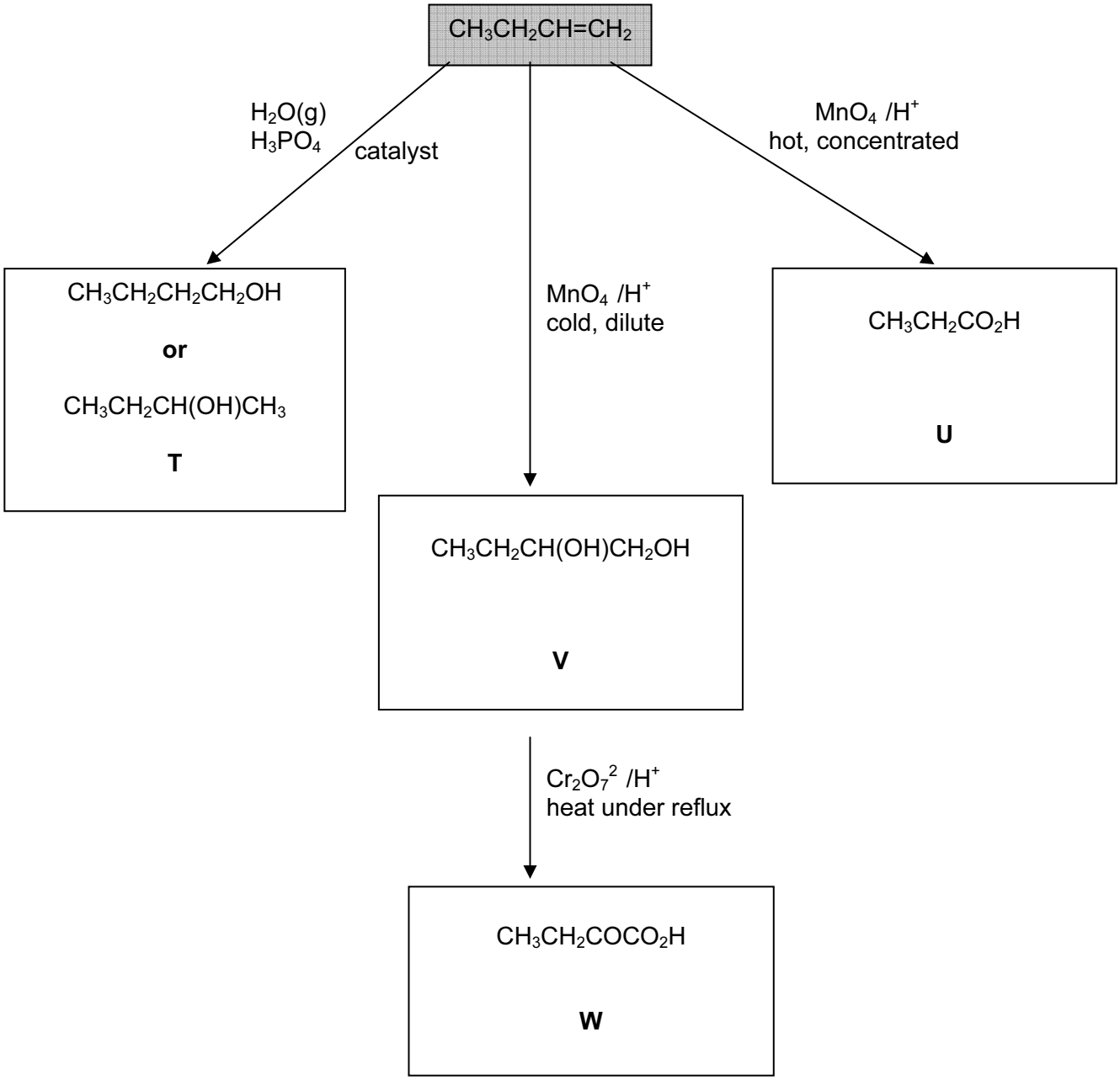
1 mol $KHCO_3 \equiv \frac{463.98 \times 1}{0.0200}$ = 23199 J

enthalpy change = +23.20 kJmol ^{1} (1) [3]

(d) ΔH = 2 × (+23.20) – (–32.60) = +79.00 kJ mol ^{1} (2) [2]

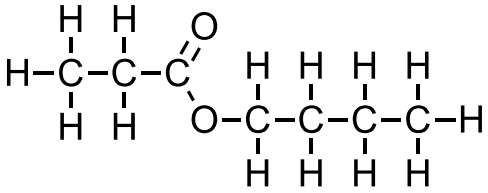
[Total: 11]

4 (a)

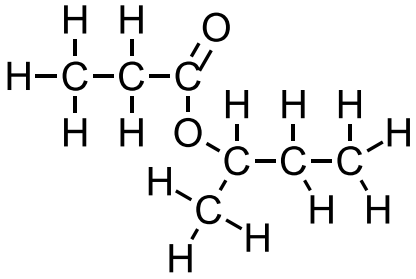


correct **T** (1)
correct **U** (1)
correct **V** (1)
correct > CO group in **W** (1)
correct $-CO_2H$ group in **W** (1) [5]

(b) T + U



or



correct structures (1)
correctly displayed ester group (1) [2]

[Total: 7]

5 (a) (i) 1 primary (1)
alcohol **not** hydroxyl (1)

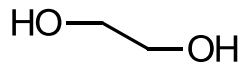
2 aldehyde **not** carbonyl (1)

(ii)

test 1			
reagent	Na	$PCl_3/PCl_5/PBr_3$	RCO_2H/H^+
observation	gas/H_2/effervescence/ fizzing	HCl/HBr steamy fumes	fruity smell
test 2			
reagent	Tollens' reagent	Fehling's reagent	2,4-dinitro-phenylhydrazine
observation	Ag mirror/silver/ black ppt	brick-red ppt red ppt	orange/red/yellow ppt/solid

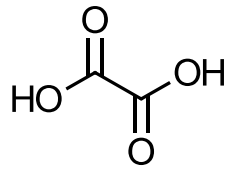
only award the observation mark if reagent is correct (4) [7]

(b) (i)



(1)

(ii)



(1) [2]

5 (c)

route	starting compound	**first reagent**	intermediate **X**	**second reagent**	intermediate **Y**	**third reagent**	final compound
A/1	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	$ClCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$ClCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
A/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
B/1	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	C/CH_2CHO	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
B/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
C	$HOCH_2CHO$	Tollens' or Fehling's reagents	$HOCH_2CO_2H$	KBr/conc. H_2SO_4	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
mark		(1)	(1)	(1)	(1)	(1)	

[5]

[Total: 14]

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9701 CHEMISTRY

9701/22 Paper 2 (AS Structured Questions), maximum raw mark 60

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= 59.89

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paired electrons repel (1) [4]

(d) **(i) and (ii)**

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conductivity	high	high	—	moderate	low	low
melting point	low	high	—	high	low	low
	(1)	(1)		(1)	(1)	(1)

one mark for each correct column [5]

(e) germanium/Ge (1) [1]

[Total: 15]

3 **(a)** the overall enthalpy change/energy change/ΔH for a reaction (1)

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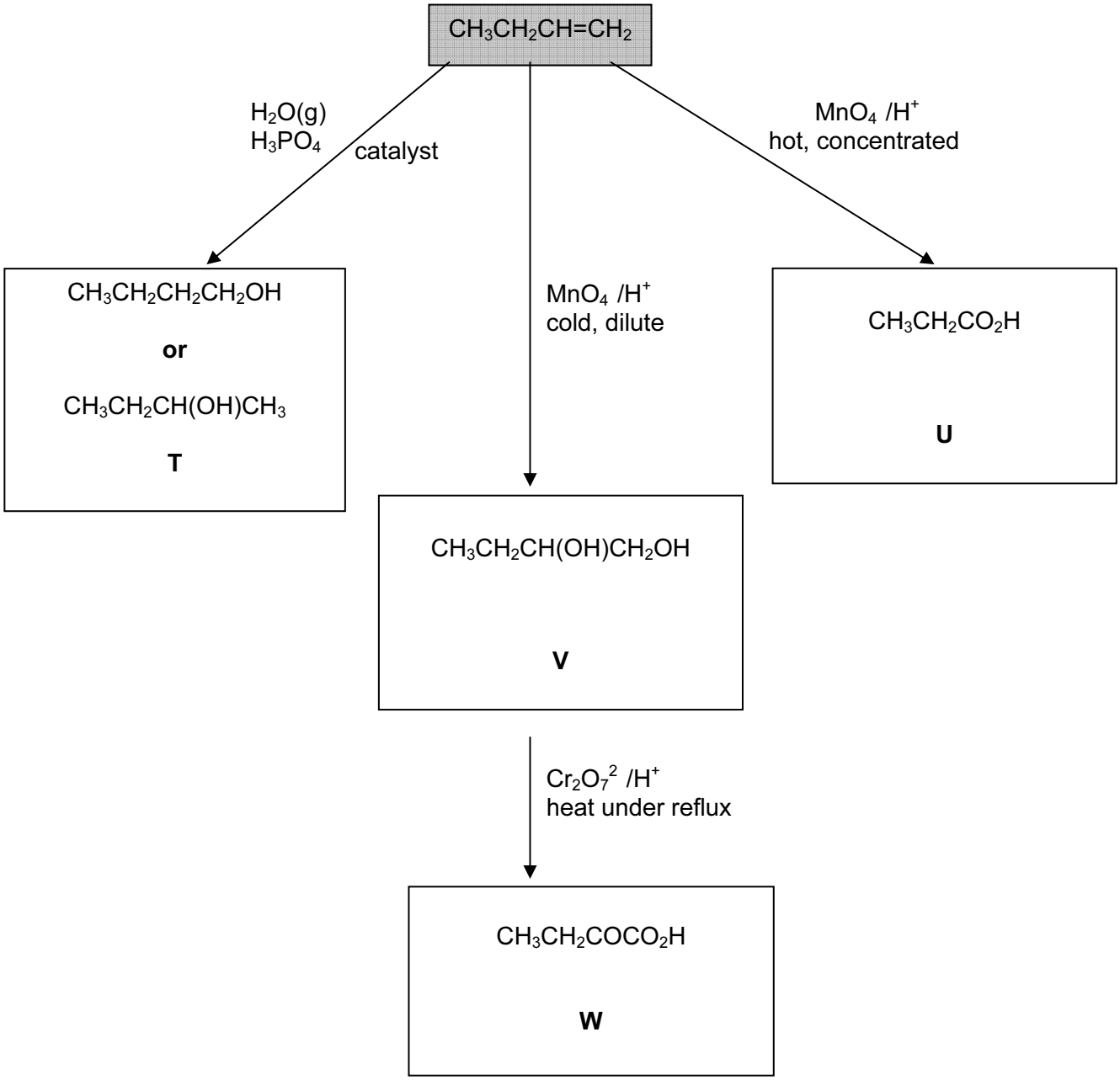
enthalpy change = +23.20 kJmol ^{1} (1) [3]

(d) ΔH = 2 × (+23.20) – (–32.60) = +79.00 kJ mol ^{1} (2) [2]

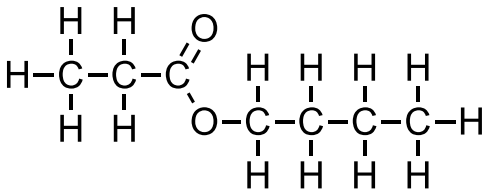
[Total: 11]

4 (a)



correct **T** (1)
correct **U** (1)
correct **V** (1)
correct > CO group in **W** (1)
correct $-CO_2H$ group in **W** (1) [5]

(b) T + U



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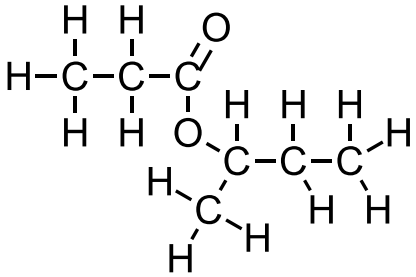


correct structures (1)
correctly displayed ester group (1) [2]

[Total: 7]

5 (a) (i) 1 primary (1)
alcohol **not** hydroxyl (1)

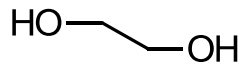
2 aldehyde **not** carbonyl (1)

(ii)

test 1			
reagent	Na	$PCl_3/PCl_5/PBr_3$	RCO_2H/H^+
observation	gas/H_2/effervescence/ fizzing	HCl/HBr steamy fumes	fruity smell
test 2			
reagent	Tollens' reagent	Fehling's reagent	2,4-dinitro-phenylhydrazine
observation	Ag mirror/silver/ black ppt	brick-red ppt red ppt	orange/red/yellow ppt/solid

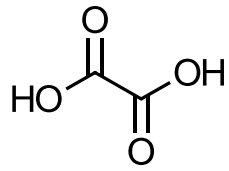
only award the observation mark if reagent is correct (4) [7]

(b) (i)



(1)

(ii)



(1) [2]

5 (c)

route	starting compound	**first reagent**	intermediate **X**	**second reagent**	intermediate **Y**	**third reagent**	final compound
A/1	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	$ClCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$ClCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
A/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
B/1	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	C/CH_2CHO	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
B/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
C	$HOCH_2CHO$	Tollens' or Fehling's reagents	$HOCH_2CO_2H$	KBr/conc. H_2SO_4	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
mark		(1)	(1)	(1)	(1)	(1)	

[5]

[Total: 14]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/23 Paper 2 (AS Structured Questions), maximum raw mark 60

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1 **(a)** same proton number/atomic number (1)
different mass number/nucleon number (1) [2]

(b) $A_r = \frac{(32 \times 95.00) + (33 \times 0.77) + (34 \times 4.23)}{100}$ (1)

$= \frac{3040 + 25.41 + 143.82}{100} = \frac{3209.23}{100}$

which gives $A_r = 32.09$ (1) [2]

(c)

	number of		
isotopes	protons	neutrons	electrons
^{213}Po	84	129	84
^{232}Th	90	142	90

allow **one mark** for each correct column
if there are no 'column' marks,
allow **maximum one mark** for a correct row (3 × 1) [3]

(d) **(i)** nucleon no. is 228 (1)
proton no. is 88 (1)

(ii) Ra **not** radium (1) [3]

[Total: 10]

2 **(a)** **(i)** mass of C = $\frac{12 \times 1.32}{44}$ = 0.36g (1)

n(C) = $\frac{0.36}{12}$ = 0.03 (1)

(ii) mass of H = $\frac{2 \times 0.54}{18}$ = 0.06 g (1)

n(H) = $\frac{0.06}{1}$ = 0.06 (1)

(iii) yes **because** 0.03 mol of C are combined with 0.06 mol of H **or**
C : H ratio is 1 : 2 **or**
empirical formula is CH_2 (1) [5]

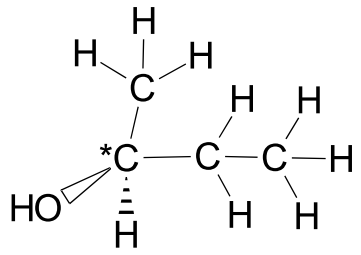
(b) (i) C : H : O = $\frac{64.86}{12}$: $\frac{13.50}{1}$: $\frac{21.64}{16}$ (1)

= 5.41: 13.50 : 1.35

= 4 : 10 : 1

gives $C_4H_{10}O$ (1)

(ii)



correct compound **and** correct chiral C* (1)
correct mirror object/ mirror
image relationship in 3D (1)

(iii)

$CH_3CH_2CH_2CH_2OH$	$CH_3C(H)(CH_3)CH_2OH$	$CH_3C(OH)(CH_3)CH_3$
(1)	(1)	(1)

[7]

[Total: 12]

3 (a) $C(g) \rightarrow C^+(g) + e$
correct equation (1)
correct state symbols (1) [2]

(b) (i) Na and Mg
Mg has greater nuclear charge/more protons than Na (1)

in both atoms, the 3s electrons are in the same orbital/
same energy level/same shell (1)

(ii) Mg and A*l*
in A*l* outermost electron is in 3p rather than 3s (1)

3p electron is at higher energy **or**
is further away/is more shielded from nucleus (1)

(iii) **He and Ne**
both He and Ne have the highest nuclear charges in their Period (1)

(iv) **He, Ne, and Ar**
going down the group,

valence/outer shell electrons are farther from the nucleus (1)

there is greater shielding (1)

attraction between valence electrons and nucleus is less **or**
effective nuclear charge is less (1) [8]

(c) **(i)** **from Na to Cl**
increased nuclear charge/nuclear attraction (1)

(ii) cation has fewer electrons than atom **or**
cation has lost outer electrons **or**
cation has fewer shells (1)

but cation has same nuclear charge as atom **or**
proton number is the same (1) [3]

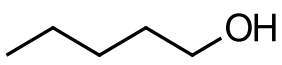
3 **(d)** ignore any state symbols

$MgO(s)$	+	$NaOH(aq)$			$\rightarrow$	NO REACTION	(1)
$MgO(s)$	+	**2**$HCl(aq)$			$\rightarrow$	$MgCl_2 + H_2O$	(1)
$Al_2O_3(s)$	+	**2**$NaOH(aq)$	+	**3**$H_2O(l)$	$\rightarrow$	**2**$NaAl(OH)_4$ **or**	(1)
$Al_2O_3(s)$	+	**2**$NaOH(aq)$	+	$H_2O(l)$	$\rightarrow$	**2**$NaAlO_2 + 2H_2O$ **or**	
$Al_2O_3(s)$	+	**6**$NaOH(aq)$	+	**3**$H_2O(l)$	$\rightarrow$	**2**$Na_3Al(OH)_6$	
$Al_2O_3(s)$	+	**6**$HCl(aq)$			$\rightarrow$	**2**$AlCl_3$ + **3**H_2O **or**	(1)
$Al_2O_3(s)$	+	**6**$HCl(aq)$			$\rightarrow$	Al_2Cl_6 + **3**H_2O	
$SO_2(g)$	+	$NaOH(aq)$			$\rightarrow$	$NaHSO_3$ **or**	(1)
$SO_2(g)$	+	**2**$NaOH(aq)$			$\rightarrow$	$Na_2SO_3 + H_2O$	
$SO_2(g)$	+	$HCl(aq)$			$\rightarrow$	NO REACTION	(1) [6]

[Total: 19]

4 **(a)** **(i)** C_2H_5O (1)

(ii)



(1) [2]

(b) (i) functional group isomerism
or structural isomerism (1)

do **not** allow 'functional isomerism' or positional isomerism

(ii)

compound	type of isomerism
P	*cis-trans* **or** geometrical
T	optical

(1 + 1) [3]

(c) (i) dehydration/elimination (1)

(ii) conc. H_2SO_4 / P_4O_{10} / Al_2O_3 / H_3PO_4 / pumice (1)

(iii) $CH_2=CHCH=CH_2$

allow $CH_2=C=CHCH_3$ (1) [3]

(d) (i) $CH_3CH_2CH(OH)CH_2CH_3$ (1)

(ii) steam with H_3PO_4 catalyst **or**
conc. H_2SO_4 then water (1 + 1)

only allow condition mark if reagent mark has been given

(iii) $Cr_2O_7^{2-}$ /H^+ **or**
MnO_4 /H^+ (1) [4]

[Total: 12]

5 (a) **V** is HCHO (1) [1]

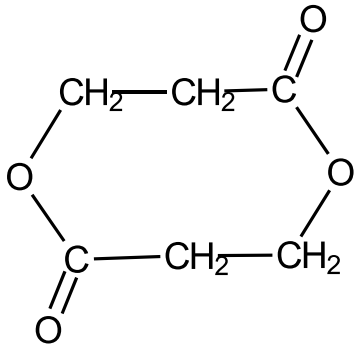
(b) (i) ester (1)

(ii) **W** is HCO_2CH_3 (1) [2]

(c) (i) **X** is $HOCH_2CH_2CO_2H$ (1)

(ii) **Y** is $HO_2CCH_2CO_2H$ (1) [2]

(d) (i) **Z** is



(1)

(ii) esterification **or**
dehydration **or**
elimination **or**
condensation (1) [2]

[Total: 7]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/31 Paper 3 (Advanced Practical Skills 1), maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark	
1 (a)	PDO Recording	**I** Thermometer readings for all experiments recorded to 0.0 or 0.5°C. (At least one recorded to 0.5°C.)	1	
	ACE Interpretation	**II** Calculation of all temperature changes correct.	1	
	MMO Quality	Award **III** for a temperature rise followed by constant temperature (within 0.5°C).	1	
		Award **IV** and **V** for a **maximum** rise within 0.5°C of supervisor.	1	
		Award **IV** for a **maximum** rise within 1.0°C of supervisor.	1	
		Award **VI** and **VII** for the experiment **3** temperature rise within 0.5°C of supervisor.	1	
		Award **VI** for the experiment **3** temperature rise within 1.0°C of supervisor.	1	[7]
(b)	PDO Layout	**I** Axes correct and labelled: temperature change/ T change/ΔT and volume/vol/V (of) sodium hydroxide/NaOH/**FA 1** **and** correct units /°C or (°C) or 'in °C'; /cm^3 or (cm^3) (allow NaOH in cm^3)	1	
		II Scales chosen so that graph occupies at least half the available length for *x*- and *y*-axes.	1	
		III Plotting – all points accurate to within half a small square and in the correct square.	1	
		IV Draws two straight lines of best fit which intersect.	1	[4]
(c)	ACE Interpretation	Reads to nearest ½ square to 1 or 2 dp volume of **FA 1** and temperature rise from intercept. Do **not** award if ΔT at intercept (or point) **<** max ΔT from table unless candidate has clearly indicated the max ΔT is anomalous.	1	[1]

(d)	ACE Conclusions	**I** The temperature/temperature change increases as **more** reaction/more hydrochloric acid/sodium hydroxide reacts/as more water formed. **II** The temperature/temperature change stays constant/decreases when all acid/limiting reagent has reacted/excess NaOH is added.	1 1	[2]
(e)	ACE Interpretation	**I** Volume used in calculation is 65 cm^3 **II** Heat energy change calculated using candidate's value for ΔT correct to 3 or 4 sf	1 1	[2]
(f)	ACE Interpretation	$\frac{25 \times 2}{1000}$ = **0.05**	1	[1]
(g)	ACE Interpretation PDO Display	**I** Candidate's answer to **(e)** / Candidate's answer to **(f)** **II** Correct calculation, conversion J to kJ and negative sign to 3 or 4 sf	1 1	[2]
(h)	ACE Conclusions	So that rise in temperature is proportional to increase in energy produced/change in volume gives different change in temperature for same energy produced/ increase in volume requires increase in energy for same temperature rise.	1	[1]
(i)	PDO Display ACE Interpretation	**I** Number moles NaOH = number moles HC*l* (stated or clearly shown) **II** Calculates or expression for Concentration = $\frac{0.05 \text{ (ecf from (f))}}{\text{answer to (c)}/1000}$ If answer only, award mark if correct to 3 or 4 sf	1 1	[2]
(j)	ACE Improvements	Use more **concentrated** solutions. (allow use **≤ 5** cm^3 water each time) Ignore all references to heat energy losses.	1	[1]
(k)	ACE Conclusions	**I** Two straight intersecting lines (positive followed by zero gradient). **II** Same ΔT and V shown as in **(b)**.	1 1	[2]
				[Total: 25]

FA 3 is $Na_2S_2O_5$(s); **FA 4** is Na_2CO_3(s); **FA 5** is Na_2SO_4(s); **FA 6** is $Pb(NO_3)_2$(s) and (aq)					
2	**(a)**	MMO Decisions	**(i)** **I** Any named mineral acid or formula or (acidified) potassium dichromate Do **not** allow any reagent suitable for testing cations or more than one reagent.	1	
		PDO Recording	**(ii)** **II** Tabulates evidence of 3 tests carried out with no repeat headings. **Only** consider observations with acid or dichromate.	1	
		MMO Collection	**III** Bubbles/effervescence in **FA 4**.	1	
			IV Slower effervescence in **FA 3** than **FA 4** or **FA 3** turns green **and FA 5** stays orange if dichromate used.	1	
		MMO Decisions	**V** Appropriate test with positive result used to test for either gas.	1	
		ACE Conclusions	**VI** All three ions correct from suitable observations. **FA3** is a sulfite. **FA4** is a carbonate. **FA5** is a sulfate. (or correct formulae)	1	[6]
	(b)	MMO Collection	**(i)** **I** **FA 4** + **FA 6** white ppt **and** **FA 5** + **FA 6** white ppt.	1	
			II **FA 6** + NaOH white ppt, soluble in excess sodium hydroxide.		
			III Brown gas		
			IV Gas relights glowing splint.		
			V Yellow residue or crackling/decrepitating.		
		ACE Conclusions	**VI** Gas identified as oxygen or as NO_2 from observations.		[6]
		ACE Conclusions	**(ii)** Lead/Pb^{2+} provided correct observations with **FA 6** + NaOH **and** **FA 6** + **FA 5** (sulfate).	1	[1]
		MMO Decisions	**(iii)** **I** Add HC*l* / H_2SO_4 / KI / K_2CrO_4 / NH_3*	1	
		MMO Collection	**II** white ppt/white ppt/yellow ppt/yellow ppt/white ppt insoluble in excess.	1	
			* If not Pb^{2+} in **(ii)** but one of Al^{3+}, Ba^{2+}, Ca^{2+}, Zn^{2+} allow suitable reagent mark: K_2CrO_4 for Ba^{2+} and NH_3 for the other three. However, observation must be correct for **Pb^{2+}**.		[2]
					[Total: 15]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/33 Paper 3 (Advanced Practical Skills 1), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark	
1 (a)	PDO Recording	**I** Thermometer readings for all experiments recorded to 0.0 or 0.5°C. (At least one recorded to 0.5°C.)	1	
	ACE Interpretation	**II** Calculation of all temperature changes correct.	1	
	MMO Quality	Award **III** for a temperature rise followed by constant temperature (within 0.5°C).	1	
		Award **IV** and **V** for a **maximum** rise within 0.5°C of supervisor.	1	
		Award **IV** for a **maximum** rise within 1.0°C of supervisor.	1	
		Award **VI** and **VII** for the experiment **3** temperature rise within 0.5°C of supervisor.	1	
		Award **VI** for the experiment **3** temperature rise within 1.0°C of supervisor.	1	[7]
(b)	PDO Layout	**I** Axes correct and labelled: temperature change/ T change/ΔT and volume/vol/V (of) sodium hydroxide/NaOH/**FA 1** **and** correct units /°C or (°C) or 'in °C'; /cm^3 or (cm^3) (allow NaOH in cm^3)	1	
		II Scales chosen so that graph occupies at least half the available length for *x*- and *y*-axes.	1	
		III Plotting – all points accurate to within half a small square and in the correct square.	1	
		IV Draws two straight lines of best fit which intersect.	1	[4]
(c)	ACE Interpretation	Reads to nearest ½ square to 1 or 2 dp volume of **FA 1** and temperature rise from intercept. Do **not** award if ΔT at intercept (or point) **<** max ΔT from table unless candidate has clearly indicated the max ΔT is anomalous.	1	[1]

(d)	ACE Conclusions	**I** The temperature/temperature change increases as **more** reaction/more hydrochloric acid/sodium hydroxide reacts/as more water formed. **II** The temperature/temperature change stays constant/decreases when all acid/limiting reagent has reacted/excess NaOH is added.	1 1	[2]
(e)	ACE Interpretation	**I** Volume used in calculation is 65 cm^3 **II** Heat energy change calculated using candidate's value for ΔT correct to 3 or 4 sf	1 1	[2]
(f)	ACE Interpretation	$\frac{25 \times 2}{1000}$ = **0.05**	1	[1]
(g)	ACE Interpretation PDO Display	**I** Candidate's answer to **(e)** / Candidate's answer to **(f)** **II** Correct calculation, conversion J to kJ and negative sign to 3 or 4 sf	1 1	[2]
(h)	ACE Conclusions	So that rise in temperature is proportional to increase in energy produced/change in volume gives different change in temperature for same energy produced/ increase in volume requires increase in energy for same temperature rise.	1	[1]
(i)	PDO Display ACE Interpretation	**I** Number moles NaOH = number moles HC*l* (stated or clearly shown) **II** Calculates or expression for Concentration = $\frac{0.05 \text{ (ecf from (f))}}{\text{answer to (c)}/1000}$ If answer only, award mark if correct to 3 or 4 sf	1 1	[2]
(j)	ACE Improvements	Use more **concentrated** solutions. (allow use **≤ 5** cm^3 water each time) Ignore all references to heat energy losses.	1	[1]
(k)	ACE Conclusions	**I** Two straight intersecting lines (positive followed by zero gradient). **II** Same ΔT and V shown as in **(b)**.	1 1	[2]
				[Total: 25]

FA 3 is $Na_2S_2O_5(s)$; **FA 4** is $Na_2CO_3(s)$; **FA 5** is $Na_2SO_4(s)$; **FA 6** is $Pb(NO_3)_2(s)$ and (aq)					
2	**(a)**	MMO Decisions	**(i)** **I** Any named mineral acid or formula or (acidified) potassium dichromate Do **not** allow any reagent suitable for testing cations or more than one reagent.	1	
		PDO Recording	**(ii)** **II** Tabulates evidence of 3 tests carried out with no repeat headings. **Only** consider observations with acid or dichromate.	1	
		MMO Collection	**III** Bubbles/effervescence in **FA 4**.	1	
			IV Slower effervescence in **FA 3** than **FA 4** or **FA 3** turns green **and FA 5** stays orange if dichromate used.	1	
		MMO Decisions	**V** Appropriate test with positive result used to test for either gas.	1	
		ACE Conclusions	**VI** All three ions correct from suitable observations. **FA3** is a sulfite. **FA4** is a carbonate. **FA5** is a sulfate. (or correct formulae)	1	[6]
	(b)	MMO Collection	**(i)** **I** **FA 4** + **FA 6** white ppt **and** **FA 5** + **FA 6** white ppt.	1	
			II **FA 6** + NaOH white ppt, soluble in excess sodium hydroxide.		
			III Brown gas		
			IV Gas relights glowing splint.		
			V Yellow residue or crackling/decrepitating.		
		ACE Conclusions	**VI** Gas identified as oxygen or as NO_2 from observations.		[6]
		ACE Conclusions	**(ii)** Lead/Pb^{2+} provided correct observations with **FA 6** + NaOH **and** **FA 6** + **FA 5** (sulfate).	1	[1]
		MMO Decisions	**(iii)** **I** Add HC*l* / H_2SO_4 / KI / K_2CrO_4 / NH_3*	1	
		MMO Collection	**II** white ppt/white ppt/yellow ppt/yellow ppt/white ppt insoluble in excess.	1	
			* If not Pb^{2+} in **(ii)** but one of Al^{3+}, Ba^{2+}, Ca^{2+}, Zn^{2+} allow suitable reagent mark: K_2CrO_4 for Ba^{2+} and NH_3 for the other three. However, observation must be correct for **Pb^{2+}**.		[2]
					[Total: 15]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/34 Paper 3 (Advanced Practical Skills 2), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark	
1 (a)	MMO Collection PDO Collection ACE Interpretation	**I** Performs experiment and records **all** sensible thermometer readings. **II** Records all thermometer readings to 0.0/0.5 °C. **III** Correctly calculates the temperature rises.	1 1 1	
	MMO Quality	Award **IV**, **V** and **VI** for a ΔT within 0.5 °C of Supervisor's result. Award **IV** and **V** for a ΔT within 1.0 °C of Supervisor's result. Award **IV** only for a ΔT within 1.5 °C of Supervisor's result.	3	
	Calculate result for 35 cm^3 by multiplying candidate's result for 30 cm^3 of **FB 1** by 0.75, round up to the nearest 0.5 °C.			
		Award **VII** and **VIII** if candidate's temperature rise for 35 cm^3 **FB 1** is within 0.5 °C of calculated value. Award **VII** only if ΔT is within 1.0 °C	2	[8]
(b)	PDO Display	**I** Axes labelled: temperature/T change or ΔT and volume/Vol/V sodium hydroxide/NaOH **and** correct units /°C or (°C) or 'in °C', /cm^3 or (cm^3). **II** Suitable scales chosen so that the points, if plotted, would occupy at least half the available length for *x*- and *y*-axes. *Do not award if 50 cm^3 not included.* **III** Plotting – accurate to within half a small square and in the correct square. **IV** Draws two straight lines of best fit which intersect. *Allow coming to a point (**not** curved). Does not have to go through (0,0).*	1 1 1 1	[4]

(c)	ACE Interpretation	**(i)** **I** Reads to nearest ½ square temperature rise to 1 dp at point of intersection. Do not award if intersection < largest ΔT.	1	
		(ii) **II** Reads to nearest ½ square volume of **FB 1** to 1 dp or nearest 0.5 cm^3 at point of intersection.	1	
		(iii) **III** Correctly calculates moles of sodium hydroxide [volume of **FB 1** in **(ii)** × 1.5/1000] to 2 to 4 sf.	1	
		(iv) **IV** Heat energy produced = 50 × 4.3 × temperature rise from **(i)**	1	
		V Correct answer calculated to 3 or 4 sf. *ecf from incorrect* ***volume***	1	
		(v) **VI** $\frac{\text{candidate's answer to (iv)}}{\text{candidate's answer to (iii)}}$	1 1	
		VII Negative sign and answer in kJ to 2 to 4 sf	1	[7]
(d)	ACE Interpretation	Identifies a source of error e.g. precision of thermometer, precision of measuring cylinder*	1	
	ACE Improvements	Suggests thermometer with smaller scale divisions (0.1°C), use of burette*	1	[2]
(e)	ACE Interpretation	**(i)** **I** Calculates or expression for the volume of **FB 2** which reacts [50 – **(c)(ii)**].	1	
		II Correctly calculates the concentration of H^+ in mol dm^{-3} (≥ 2 sf) [**(c)(iii)** × 1000/{50 – **(c)(ii)**}].	1	
	PDO Display	**(ii)** **III** Divides the answer from **(i)** by 2	1	
	Decisions	**(iii)** **IV** Describes test and result for sulfate ion. White ppt with (aq) barium chloride or nitrate	1	[4]
				[Total: 25]

* e.g.	1st mark	2nd mark
	use more sensitive thermometer	0.5, 0,2, 0.1ºC or smaller % error
	smaller divisions in measuring cylinder	burette or decrease % error
	use burette as more accurate	
	cup has little water, use dry cup	
	10 cm^3 too small to take T, start with 20 cm^3	

	FB 3 is $Na_2CO_3(aq)$; **FB 4** is $Na_2CrO_4(aq)$; **FB 5** is NaBr; **FB 6** is MnO_2					
2	**(a)**	PDO Recording MMO Collection	**(i)**	**I**	All observations in a single table (2 × 3) No repeat of headings & ≥ 4 boxes filled. Observations for **both** tests on each solution are correct.	1
				II	**FB 3**	1
				III	**FB 4**	1
				IV	**FB 5**	1

Solution	H_2SO_4	$Pb(NO_3)_2$
FB 3	bubbling/effervescence **and** CO_2 identified by test (allow **gas** turns limewater milky)	white ppt
FB 4	turns orange/orange (solution) forms (**not** ppt but not CON for identity)	yellow ppt
FB 5	no change/no reaction [not " – "]	white ppt

	ACE Conclusions			**V**	**FB 3** carbonate/CO_3^{2-} from effervescence **or** positive limewater test	1
				VI	**FB 4** chromate(VI)/chromate/CrO_4^{2-} from either observation but no CON obs	1 [6]
	MMO Decisions Collection	**(ii)**	**I**		Addition of (aq) silver nitrate to **FB 5**. ***ecf*** *on obs in table if no ppt with* ***FB 5*** *+* Pb^{2+}	1
			II		**Cream** ppt (white ppt loses **II** and **III**) If NH_3 used obs must be correct.	1
	ACE Conclusions		**III**		**FB 5** bromide/Br from cream ppt (or off-white ppt insol or partially soluble in NH_3)	1 [3]
	(b)	MMO Collection	**(i)**	**I**	(bubbling/effervescence and) gas rekindles glowing splint	1
			(ii)	**II**	filtrate is yellow/qualified yellow/yellowish green/light brown **and** produces a red-brown/brown/rust/black (not red) ppt with aqueous sodium hydroxide	1
			(iii)	**III**	filtrate is green/qualified green	1
				IV	filtrate turns purple/pink (with acid)	1
		ACE Conclusions		**V**	**(i)** **FB 6** is a catalyst *Allow* O_2 *formed or* H_2O_2 *decomposes* ***if*** *glowing splint test correct.*	1
				VI	**(ii)** **FB 6** is an oxidant/oxidising agent/is reduced.	1 [6]
						[Total: 15]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/35 Paper 3 (Advanced Practical Skills 1), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark	
1 (a)	PDO Layout Recording	**I** Pairs of thermometer readings and time unambiguously recorded. *Minimum of three pairs.*	1	
		II Correct headings and units. *Units must have solidus: /s; brackets: (s); or describe in words: time in seconds or time in s, solidus/°C; or brackets (°C); or describe in words: temperature in °C. No repeats of unit in table to individual readings.*	1	
		III Time recorded to 1 second and temperature to 0.5°C. (Must have at least one at 0.5°C.)	1	
	MMO Decisions	**IV** Five (minimum) different experiments carried out.	1	
		V Initial temperatures span the range specified in the question. At least 1 at or below 40°C, at least 1 above 50°C and no two within 3°C (minimum 3 readings). If more than 5 readings can be within 3°C.	1	[5]
(b)	ACE Interpretation	**I** Correct means and rates for highest 2 temperatures and lowest 2 temperatures. *Use candidate's times (not corrected).*	1	
	PDO Display MMO Quality	**II** 1000/time recorded 3–4sf.	1	
	Calculate log rate for chosen temperatures. Calculate $\frac{\text{log rate 2} \quad \text{log rate 3}}{\text{T2} \quad \text{T3}}$ to 3 significant figures (factor A). Calculate (T1 – T2) × factor A and add this to log rate 2. Compare this value with candidate's log rate for T1 and calculate δ.			
	If δ > 0.05 but < or = 0.10 award **III**,		1	
	If δ < or = 0.05 award **III** and **IV**.		1	
	Repeat for (T3 – T4) × factor A and subtract from log rate T3.			
	If δ > 0.05 but < or = 0.10 award **V**,		1	
	If δ < or = 0.05 award **V** and **VI**.		1	
	If 3 experiments, use slowest 2 for 'standard' and award Q marks for fastest (maximum 2)			[6]

(c)	PDO Layout	**(i)** **I** All points plotted to use at least 5 large squares on vertical axis and 4 on horizontal axis including position of 20°C.	1	
		II *x*-axis to allow extrapolation to 20°C.	1	
		III An appropriate line of best fit is drawn.	1	
	ACE Interpretation	**(ii)** **IV** Correct value to 0.5°C or 1 dp of 1000/t **from graph** *(ignore units).*	1	[4]
(d)	PDO Display	Uses temperature values **10** apart from graph and quotes rates/chooses rates that are doubled and quotes temperatures.	1	
	ACE Conclusions	Relevant comment on data made. This can come from experimental results.	1	[2]
(e)	ACE Interpretation	**(i)** Fastest reaction/first reaction.	1	
		(ii) Expression for % error ecf from **(i)**.	1	[2]
(f)	ACE Interpretation	Temperature change is not the same for each run of the mixture/**FA 2** not at the same temperature as **FA 1** before mixing/difficulty of gauging same level of colour/cannot start clock and pour solutions at same time/reusing boiling tubes could affect concentration. *Not: human error/heat loss or gain/human reaction time.*	1	[1]
(g)	ACE Improvements	Use of thermostatically controlled water bath/data logger for colour intensity/colorimeter/get help from another student. *Improvement must correspond to error specified. Not: automatic timer.*	1	[1]
(h)	ACE Improvements	Same volume **FA 2**.	1	
		Change volume of **FA 1 and** keep total volume constant by adding water for several volumes of **FA 1**.	1	
		All experiments carried out at the same temperature.	1	[3]
				[Total: 24]

FA 3 is $BaCl_2$ or $Ba(NO_3)_2$; **FA 4** is H_2SO_4; **FA 5** is $NH_4Cl + Na_2SO_3$					
2	**(a)**	MMO Decisions PDO Layout MMO Collection	**(i)** **I** Selects named reagent involving CrO_4^{2-} or CO_3^{2-} (solution) or magnesium. **(ii)** **II** Tabulates evidence of three tests carried out with no repeat headings (irrespective of reagents). **III** **FA 3** yellow ppt or white ppt or no change. **IV** **FA 4** (yellow solution turns) orange or effervescence or effervescence. **V** **FA 5** yellow solution/no reaction/no reaction. *Do not allow NaOH for **I** but allow observations to include T rise for **FA 4**.* *If acid as reagent can score only **II**.* *Acidified potassium dichromate is 1 reagent.* *Do not credit as reagent but credit all observations **FA 3** yellow ppt, **FA 4** no change, **FA 5** green.*	1 1 1 1 1	[5]
	(b)	MMO Collection	**I** **FA 3** + **FA 4** white ppt. **II** **FA 4** + **FA 5** no reaction **or** slow effervescence. **III** **FA 5** + **FA 3** white ppt. **IV** ppt insoluble in HC*l* in **(i)** and soluble in HC*l* in **(iii)**.	1 1 1 1	[4]
	(c)	MMO Collection	Mark vertical columns **FA 3** no ppt/ignore **faint/slight** white ppt. **FA 5** no ppt and **gas/ammonia** turning red litmus blue on warming. **FA 4** no visible reaction. Cross out any identified as acid in **(a) (iii)**.	2	[2]

(d)	ACE Conclusions	All conclusions must follow observations. For each unknown. One mark for ion and one mark for satisfactory evidence. **FA 3** must be Ba^{2+} or Ca^{2+} to gain credit. **FA 3** if CrO_4^{2} in **(a) (i)**, Ba^{2+} (1). Evidence: yellow ppt or white ppt with **FA 4**/H_2SO_4 **and** no ppt/(faint) white ppt with NaOH (1) (Must have 2 pieces of evidence.) If CrO_4^{2} not used in **(a) (i)** Ba^{2+} and/or Ca^{2+} (1). Evidence: faint white/no ppt NaOH **and** white ppt with **FA 4**/sulfuric acid/no NH_3 when heated with NaOH (1). (Must have 2 pieces of evidence.). **FA 5** NH_4^{+} (1). Evidence: formation NH_3 in **(c)** (1). SO_3^{2} (1). Evidence: formation SO_2 in **(a)** or **(b)** (1).	1 1 1 1	[4]
(e)	MMO Decisions	Cream ppt (not off white) with $AgNO_3$ (partially soluble/insoluble in aq NH_3)	1	[1]
				[Total: 16]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/36 Paper 3 (Advanced Practical Skills 2), maximum raw mark 40

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark	
1 (a)	PDO Layout	Constructs a table for results to show volume **FB 1**, volume distilled water and time.	1	
	PDO Recording	Correct headings and units. *Units must have solidus: /s; brackets: (s); or describe in words: time in seconds or time in s. Units of volume: cm^3 with solidus etc. as above.* *All recorded readings must have units.* If units in headings they must not be repeated for each individual reading.	1	
		All times recorded to 1 second. Volumes of **FB 1** and water to 1 or 0.05 cm^3.	1	[3]
(b)	MMO Decision	Two additional volumes of propanone chosen both of which are less than 20 cm^3. *These must not be more than one in the region 20–14, 14–8 and < 8 and not within 1 cm^3 of the original values.*	1	
	MMO Collection	In both additional experiments water is added to make a total of 20 cm^3. *Some **FB 1** must be used.*	1	[2]
(c)	PDO Display	**(i)** Working shown and answer = 5 × 10 ^{5} mol.	1	
		(ii) Working shown and answer = (5 × 10 ^{5}) / 0.050 = 1 × 10 ^{3} ecf from **(i)**.	1	[2]
(d)	ACE Interpretation	Calculates the rate correctly using ans **(c) (ii)** × 10^5/ time. *Answers given to minimum 2 sig figs.*	1	
	PDO Recording	Units for rate given as mol dm ^{3}s ^{1}.	1	[2]

(e)	PDO Layout	**I** Rate on *y*-axis and volume on *x*-axis. Axes clearly labelled.	1	
		II Uniform scale chosen to use at least 6 large squares on *y*-axis and 4 on *x*-axis. This can include 0,0 if point plotted or line extrapolated. Ignore extrapolation > 20.	1	
		III Plotting of points. Points to be within ½ small square and in correct square. All recorded values should be plotted.	1	
		IV Draws a line of best fit.	1	
	MMO Quality	Award **V** and **VI** for δ = ± 3 s	1	
		Award **V** only for δ= ± 6 s	1	
		Award **VII** and **VIII** for δ = ± 8 s	1	
		Award **VII** only for δ = ± 16 s	1	[8]
(f)	ACE Conclusion	Notes linear relationship/(directly) proportional/ reaction is 1st order with respect to propanone. Rate increases as concentration (volume) increases would score one.	2	
	ACE Improvement	Other volumes of **iodine** and repeat for varying volumes of propanone/repeat values for each run/carry out **all** experiments again/repeat any anomalous results/use burettes for **FB 2 OR FB 3/** carry out **relevant** specified experiments/use a colorimeter/use starch to show colour change/ minimise intervals in volumes used. *Do not allow: carry out more experiments/use other volumes of **propanone**/do experiments again/effects of changing conditions.*	1	[3]
(g)	MMO Decision	Uses 5 cm^3 of iodine solution with extra 5 cm^3 of distilled water.	1	
	ACE Interpretation	Uses the expression **(c) (ii)**/2 and time from **(g)**. *Time must be different from that in **(d)**.*	1	[2]
(h)	ACE Conclusion	Makes logical statement to compare rate with corresponding rate in **(d)**.	1	[1]

(i)	ACE Interpretation	Uncertainty in each measurement is 0.05 cm^3/0.1 cm^3 is overall burette error. $\frac{0.10}{20.0} \times 100 = 0.50\%$ 0.50 alone scores 2 *$\frac{0.05}{20.0} \times 100 = 0.25\%$ scores 1*	1 1	[2]
				[Total: 25]

FB 4 is H_2SO_4; **FB 5** is $Pb(NO_3)_2$; **FB 6** is $(NH_4)_2CO_3$				
2 (a)	MMO Decision	**(i)** Named reagent involving CrO_4^{2-} or CO_3^{2-} solution/ Mg. *Allow NaOH **only** if increase in T for **FB 4** is used.*	1	
	MMO Collection	**(ii)** **FB 4** gives orange solution/**FB 4** gives effervescence/ / **FB 4** gives effervescence *Gas liberated not allowed unless test for gas given*. **FB 5** gives yellow ppt/white ppt/no reaction/black ppt. **FB 6** gives yellow solution/no reaction/no change.	3	[4]
(b)	MMO Collection	**FB 4** + **FB 5 and FB 5** + **FB 6** white ppt. **FB 6** + **FB 4** effervescence/bubbling. **Gas** turns limewater milky/cloudy/chalky.	1 1 1	[3]
(c)	PDO Recording	Presents information in a table to include both reagents and excess of each. *Ignore anything described as the acid in **(a)**.* *No additional reagents allowed.* **FB 5** gives white ppt soluble in excess NaOH and white ppt insol in excess NH_3(aq). **FB 6** gives no reaction with either NaOH or NH_3(aq). (Warms **FB 6** + NaOH and tests) gas/ammonia turns damp red litmus blue. **FB 4** no change scores 1.	1 1 1 1	[4]

(d)	ACE Conclusions	All conclusions must follow observations. For each unknown. One mark for ion and one mark for satisfactory evidence.		
		FB 5 If CrO_4^{2-} in **(a)**, Pb^{2+} (1)	1	
		Evidence: yellow ppt and white ppt with NaOH or NH_3 (1)	1	
		or if not CrO_4^{2-} in **(a)** Al^{3+} or Pb^{2+} (both needed) (1)		
		Evidence NH_3 (ignore NaOH) (1)		
		One of Al^{3+} or Pb^{2+} can score MP 2.		
		FB 6 NH_4^+/ CO_3^{2-} (1)	1	
		Evidence: formation of NH_3/CO_2 from appropriate tests (1)	1	
		or FB 6 Ba^{2+} or NH_4^+ (both needed) (1)		
		Evidence: no ppt **both** NaOH and NH_3 (1)		[4]
				[Total: 15]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

1 (a) (i) *either* burn *or* shine light/uv on mixture of H_2 + Cl_2 *but* NOT heat [1]

(ii) red/orange/brown colour of bromine decolourises/disappears
steamy/misty/white fumes produced
container gets warm/hot [2]

(iii) H-H = 436 Cl-Cl = 244 H-Cl = 431

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

H-H = 436 Br-Br = 193 H-Br = 366

$\Delta H = 436 + 193 - 2(366) = -103$ kJ mol^{-1} [2]

(iv) H-Br bond is weaker than the H-Cl bond – allow converse. [1]
[8]

(b) (i) light [1]

(ii) bonds broken = C-H & I-I = 410 + 151 = 561
bonds made = C-I & H-I = 240 + 299 = 539
ΔH = 551 – 539 = +22 kJ mol^{-1} [2]

(iii) The overall reaction is endothermic *or* no strong bonds/only weak bonds are formed *or* high E_{act} [1]
[4]

(c) (i) homolytic fission is the breaking of a bond to form (two) radicals/neutral species/ odd-electron species [1]

(ii) •CH_2Cl [1]
the C-Br bond is the weakest or needs least energy to break/breaks most easily [1]
[3]

(d)

4 structures: [2]
2 or 3 structures: [1]

Correct chiral atom identified [1]
[3]

[Total: 18]

2 (a) (i) Order w.r.t. $[CH_3CHO]$ = 1 [1]
Order w.r.t. $[CH_3OH]$ = 1 [1]
Order w.r.t. $[H^+]$ = 1 [1]

(ii) rate = $k[CH_3CHO][CH_3OH][H^+]$ [1]

(iii) units = mol ^{2} dm^{6} s ^{1} [1]

(iv) rate will be 2 × 4 = 8 times as fast as reaction 1 (relative rate = 8) [1]
[6]

(b)

	$[CH_3CHO]$ /mol dm ^{3}	$[CH_3OH]$ /mol dm ^{3}	$[H^+]$ /mol dm ^{3}	[acetal **A**] /mol dm ^{3}	$[H_2O]$ /mol dm ^{3}
at start	0.20	0.10	0.05	0.00	0.00
at equilibrium	(0.20 – x)	***(0.10 – 2x)***	***0.05***	x	***x***
at equilibrium	***0.175***	***0.05***	***0.05***	0.025	***0.025***

(i) 3 values in second row 3 x [1]

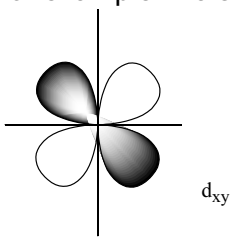
(ii) 4 values in third row 4 x [1]

(iii) K_c = $\{[\text{acetal } \mathbf{A}][H_2O]\}/\{[CH_3CHO][CH_3OH]^2\}$ [1]
units = mol ^{1}dm^{3} [1]

(iv) K_c = $0.025^2/(0.175 \times 0.05^2)$ = **1.4(3)** (mol ^{1} dm^{3}) [1]
[max 9]

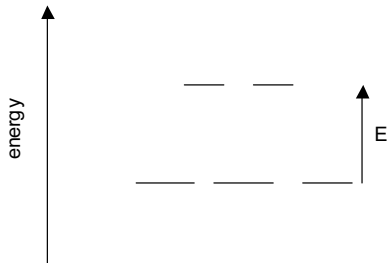
[Total: 15]

3 **(a)** for example.... also allow d_{z2}



shape (4 lobes) [1]
correct label e.g. d_{xy} [1]
[2]

(b) **(i)**



Marks are for 5 degenerate orbitals [1]
and 3:2 split [1]

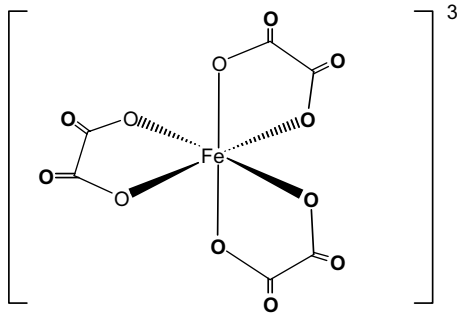
(ii) colour due to the absorption of light NOT emitted light [1]
E = hf *or* photon's energy = E in above diagram [1]
electron promoted from lower to higher orbital [1]

size of ΔE depends on the ligand [1]
as ΔE changes, so does f in E = hf [1]
[7]

(c) **(i)** O.N.(carbon) = +3 (4 × (–2) + 2x = –2, thus 2x = +6) [1]

(ii) O.N. = +3 [1]

(iii)



[2]

(iv) **2** $K_3Fe(C_2O_4)_3 \rightarrow$ **3** $K_2C_2O_4$ + **2** FeC_2O_4 + **2** CO_2 [2]
Or $K_3Fe(C_2O_4)_3 \rightarrow$ **3/2** $K_2C_2O_4 + FeC_2O_4 + CO_2$

[max 5]

[Total: 14]

4 (a) (i) $C_2H_5NH_2 + HA \rightarrow C_2H_5NH_3^+ + A$ (HA can be H_2O, HC*l* etc.) [1]
Allow $\rightleftharpoons$ instead of arrow

(ii)

most basic		least basic
ethylamine	**ammonia**	**phenylamine**

[1]

(iii) ethylamine > NH_3 due to electron-donating ethyl/alkyl group [1]
phenylamine < NH_3 due to delocalisation of lone pair over ring [1]
[4]

(b) (i) $C_6H_5OH + OH \rightarrow C_6H_5O + H_2O$ (*or* with Na^+/H_2O/A) [1]

(ii) pKa of nitrophenol is smaller/K_a is larger because it's a stronger acid/dissociates more than phenol [1]
stronger because the anionic charge is spread out moreover the NO_2 group *or* NO_2 is electron-withdrawing [1]

(iii) pKa = 1.0 [1]

(iv) Nitro group increases acidity / electron-withdrawing groups increase acidity [1]
[5]

(c) (i) **B** is phenyldiazonium cation, $C_6H_5–N^+\equiv N$ [1]

(ii)

reaction	reagent(s)	conditions
Step 1	**$NaNO_2$ + HC*l*** **or HNO_2** [1]	**T < 10°C** [1]
Step 2	**H_2O / aq**	**heat/boil/T > 10°** (both) [1]
Step 3	**HNO_3** **NB HNO_3(aq) OK for both**	**dilute** (both) [1]

[4]
[5]

[Total: 14]

5 **(a)** **(i)** C=C double bonds / alkenes

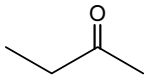
(ii) –OH groups / accept alcohols or acids

(iii) $CH_3CO–$ or $CH_3CH(OH)–$ groups

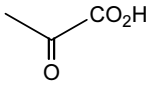
(iv) carbonyl, >C=O, groups / accept aldehydes and ketones — 4 × [1]

[4]

(b)



D

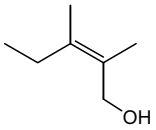


E

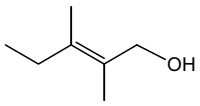
2 × [1]

[2]

(c) isomers of **C**



cis



trans

correct structure (excl. stereochemistry) [1]
cis and trans drawn correctly [1]
type of isomerism is **cis-trans *or* geometrical isomerism** [1]

[3]

[Total: 9]

6 (a) (i) $2H_2NCH_2CO_2H \rightarrow H_2NCH_2CONHCH_2CO_2H + H_2O$ [1]

(ii) Skeletal formula required [1]
[2]

(b) (i) α helix [1]
β pleated sheet [1]

(ii) **Students should choose one of the structures below**

For α helix:	For β pleated sheet:
Need to show a helix with C=O - - - H-N between turns	Need to show two parallel 'zig-zag' strands with C=O - - - H-N between them

Whichever is chosen, overall structure [1] position of H bonds [1]

[4]

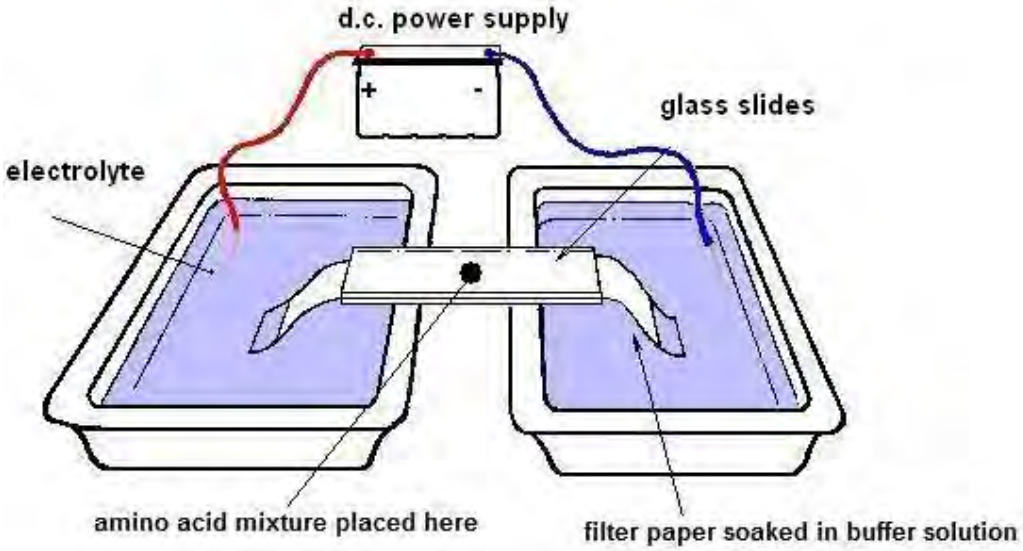
(c)

amino acid residue 1	amino acid residue 2	type of bonding
–HNCH($CH_2CH_2CH_2CH_2NH_2$)CO–	HNCH($CH_2CH_2CO_2H$)CO–	Ionic bonds or hydrogen bonds
–HNCH(CH_3)CO–	–HNCH(CH_3)CO–	van der Waals'
–HNCH(CH_2SH)CO–	–HNCH(CH_2SH)CO–	Disulfide bonds
–HNCH(CH_2OH)CO–	–HNCH(CH_2CO_2H)CO–	Hydrogen bonds

[4]

[Total: 10]

7 **(a)** Sketch and label the apparatus used to carry out electrophoresis e.g



Marks: power supply / electrolyte + filter paper / buffer / acid mixture central — 4 × [1]
[4]

(b) **(i)** pH of the buffer — [1]
Charge on the amino acid species — [1]

(ii) Size of the amino acid species / M_r — [1]
Voltage applied — [1]
Magnitude of the charge (on the amino acid species) — [1]
Temperature — [1]
(max 3)
[max 3]

(c) **(i)** They have insufficient electron density / only one electron — [1]
(ii) Sulfur — [1]
because it has the greatest atomic number / number of electrons — [1]
[3]

[Total: 10]

8 (a)

traditional material	modern polymer used
Paper/cardboard/wood/leaves hessian/hemp/jute steel/aluminium	PVC in packaging
Cotton/wool/linen	*Terylene* in fabrics
Glass/china/porcelain/earthenware metal/leather	Polycarbonate bottle

3 → 2 marks, 2 → 1 mark
[2]

(b) Reasons: Plastics/polymers pollute the environment for a long time do not decompose/ biodegrade quickly [1]
They are mainly produced from oil [1]
Produce toxic gases on burning [1]
max two

Strategy 1: Recycle polymer waste / use renewable resources [1]
Strategy 2: Develop biodegradable polymers [1]
[max 3]

(c) PVC [1]
Combustion would produce HC*l* / dioxins as a pollutant [1]
or
nylon/acrylic [1]
Combustion would produce HCN [1]
[2]

(d) (i) Polythene (or other addition polymer) [1]

(ii) Addition polymerisation [1]

The polymer chains don't have strong bonds between them – easy to melt [1]
Could be answered with a suitable diagram **[3]**

[Total: 10]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
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[3]

(d)

4 structures: [2]
2 or 3 structures: [1]

Correct chiral atom identified [1]
[3]

[Total: 18]

2 (a) (i) Order w.r.t. $[CH_3CHO]$ = 1 [1]
Order w.r.t. $[CH_3OH]$ = 1 [1]
Order w.r.t. $[H^+]$ = 1 [1]

(ii) rate = $k[CH_3CHO][CH_3OH][H^+]$ [1]

(iii) units = mol ^{2} dm^{6} s ^{1} [1]

(iv) rate will be 2 × 4 = 8 times as fast as reaction 1 (relative rate = 8) [1]
[6]

(b)

	$[CH_3CHO]$ /mol dm ^{3}	$[CH_3OH]$ /mol dm ^{3}	$[H^+]$ /mol dm ^{3}	[acetal **A**] /mol dm ^{3}	$[H_2O]$ /mol dm ^{3}
at start	0.20	0.10	0.05	0.00	0.00
at equilibrium	(0.20 – x)	***(0.10 – 2x)***	***0.05***	x	***x***
at equilibrium	***0.175***	***0.05***	***0.05***	0.025	***0.025***

(i) 3 values in second row 3 x [1]

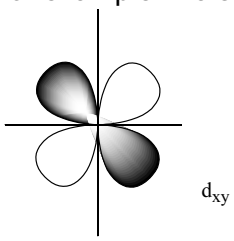
(ii) 4 values in third row 4 x [1]

(iii) K_c = $\{[\text{acetal } \mathbf{A}][H_2O]\}/\{[CH_3CHO][CH_3OH]^2\}$ [1]
units = mol ^{1}dm^{3} [1]

(iv) K_c = $0.025^2/(0.175 \times 0.05^2)$ = **1.4(3)** (mol ^{1} dm^{3}) [1]
[max 9]

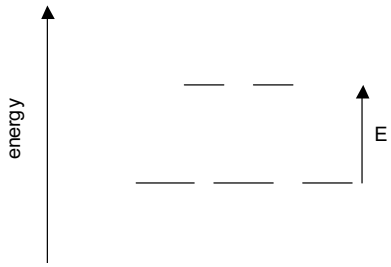
[Total: 15]

3 **(a)** for example.... also allow d_{z2}



shape (4 lobes) [1]
correct label e.g. d_{xy} [1]
[2]

(b) **(i)**



Marks are for 5 degenerate orbitals [1]
and 3:2 split [1]

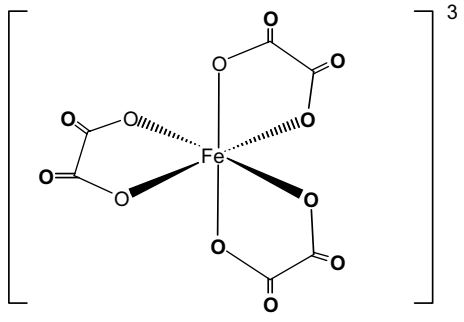
(ii) colour due to the absorption of light NOT emitted light [1]
E = hf *or* photon's energy = E in above diagram [1]
electron promoted from lower to higher orbital [1]

size of ΔE depends on the ligand [1]
as ΔE changes, so does f in E = hf [1]
[7]

(c) **(i)** O.N.(carbon) = +3 $(4 \times (-2) + 2x = -2$, thus $2x = +6)$ [1]

(ii) O.N. = +3 [1]

(iii)



[2]

(iv) **2** $K_3Fe(C_2O_4)_3 \rightarrow$ **3** $K_2C_2O_4$ + **2** FeC_2O_4 + **2** CO_2 [2]
Or $K_3Fe(C_2O_4)_3 \rightarrow$ **3/2** $K_2C_2O_4 + FeC_2O_4 + CO_2$

[max 5]

[Total: 14]

4 (a) (i) $C_2H_5NH_2 + HA \rightarrow C_2H_5NH_3^+ + A$ (HA can be H_2O, HC*l* etc.) [1]
Allow $\rightleftharpoons$ instead of arrow

(ii)

most basic		least basic
ethylamine	**ammonia**	**phenylamine**

[1]

(iii) ethylamine > NH_3 due to electron-donating ethyl/alkyl group [1]
phenylamine < NH_3 due to delocalisation of lone pair over ring [1]
[4]

(b) (i) $C_6H_5OH + OH \rightarrow C_6H_5O + H_2O$ (*or* with Na^+/H_2O/A) [1]

(ii) pKa of nitrophenol is smaller/K_a is larger because it's a stronger acid/dissociates more than phenol [1]
stronger because the anionic charge is spread out moreover the NO_2 group *or* NO_2 is electron-withdrawing [1]

(iii) pKa = 1.0 [1]

(iv) Nitro group increases acidity / electron-withdrawing groups increase acidity [1]
[5]

(c) (i) **B** is phenyldiazonium cation, $C_6H_5–N^+{\equiv}N$ [1]

(ii)

reaction	reagent(s)	conditions
Step 1	**$NaNO_2$ + HC*l*** **or HNO_2** [1]	**T < 10°C** [1]
Step 2	**H_2O / aq**	**heat/boil/T > 10°** (both) [1]
Step 3	**HNO_3** **NB HNO_3(aq) OK for both**	**dilute** (both) [1]

[4]
[5]

[Total: 14]

5 **(a)** **(i)** C=C double bonds / alkenes

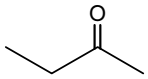
(ii) –OH groups / accept alcohols or acids

(iii) $CH_3CO–$ or $CH_3CH(OH)–$ groups

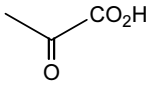
(iv) carbonyl, >C=O, groups / accept aldehydes and ketones — 4 × [1]

[4]

(b)



D

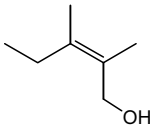


E

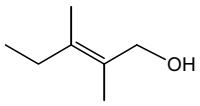
2 × [1]

[2]

(c) isomers of **C**



cis



trans

correct structure (excl. stereochemistry) [1]
cis and trans drawn correctly [1]
type of isomerism is **cis-trans *or* geometrical isomerism** [1]

[3]

[Total: 9]

6 (a) (i) $2H_2NCH_2CO_2H \rightarrow H_2NCH_2CONHCH_2CO_2H + H_2O$ [1]

(ii) Skeletal formula required [1]
[2]

(b) (i) α helix [1]
β pleated sheet [1]

(ii) **Students should choose one of the structures below**

For α helix:
Need to show a helix with C=O - - - H-N between turns

For β pleated sheet:
Need to show two parallel 'zig-zag' strands with C=O - - - H-N between them

Whichever is chosen, overall structure [1] position of H bonds [1]

[4]

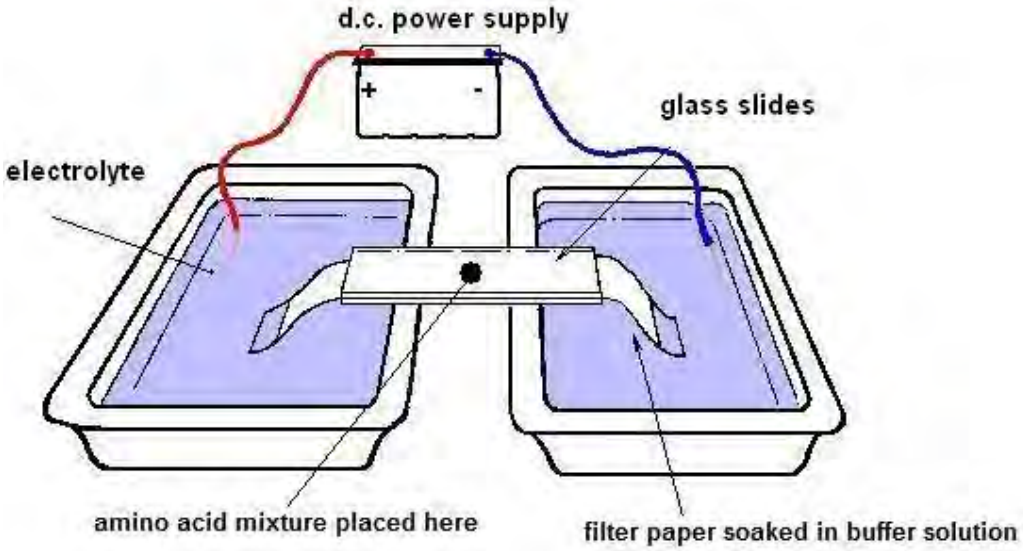
(c)

amino acid residue 1	amino acid residue 2	type of bonding
$–HNCH(CH_2CH_2CH_2CH_2NH_2)CO–$	$HNCH(CH_2CH_2CO_2H)CO–$	Ionic bonds or hydrogen bonds
$–HNCH(CH_3)CO–$	$–HNCH(CH_3)CO–$	van der Waals'
$–HNCH(CH_2SH)CO–$	$–HNCH(CH_2SH)CO–$	Disulfide bonds
$–HNCH(CH_2OH)CO–$	$–HNCH(CH_2CO_2H)CO–$	Hydrogen bonds

[4]

[Total: 10]

7 **(a)** Sketch and label the apparatus used to carry out electrophoresis e.g



Marks: power supply / electrolyte + filter paper / buffer / acid mixture central — 4 × [1]
[4]

(b) **(i)** pH of the buffer — [1]
Charge on the amino acid species — [1]

(ii) Size of the amino acid species / M_r — [1]
Voltage applied — [1]
Magnitude of the charge (on the amino acid species) — [1]
Temperature — [1]
(max 3)
[max 3]

(c) **(i)** They have insufficient electron density / only one electron — [1]
(ii) Sulfur — [1]
because it has the greatest atomic number / number of electrons — [1]
[3]

[Total: 10]

8 (a)

traditional material	modern polymer used
Paper/cardboard/wood/leaves hessian/hemp/jute steel/aluminium	PVC in packaging
Cotton/wool/linen	*Terylene* in fabrics
Glass/china/porcelain/earthenware metal/leather	Polycarbonate bottle

3 → 2 marks, 2 → 1 mark
[2]

(b) Reasons: Plastics/polymers pollute the environment for a long time do not decompose/ biodegrade quickly [1]
They are mainly produced from oil [1]
Produce toxic gases on burning [1]
max two

Strategy 1: Recycle polymer waste / use renewable resources [1]
Strategy 2: Develop biodegradable polymers [1]
[max 3]

(c) PVC [1]
Combustion would produce HC*l* / dioxins as a pollutant [1]
or
nylon/acrylic [1]
Combustion would produce HCN [1]
[2]

(d) (i) Polythene (or other addition polymer) [1]

(ii) Addition polymerisation [1]

The polymer chains don't have strong bonds between them – easy to melt [1]
Could be answered with a suitable diagram **[3]**

[Total: 10]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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Cambridge is publishing the mark schemes for the October/November 2011 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

UNIVERSITY of CAMBRIDGE
International Examinations

1 **(a)** Cr^{3+}: $1s^2 2s^2 2p^6$ **$3s^2$ $3p^6$ $3d^3$** [1]
Mn^{2+}: $1s^2 2s^2 2p^6$ **$3s^2$ $3p^6$ $3d^5$** [1]
[2]

(b) **(i)** Any two from
- H^+ is on the oxidant/L.H. side of each of the ½-equations, *or* H^+ is a reactant
- (increasing $[H^+]$) will make $E^\ominus$ more positive
- (increasing $[H^+]$) will drive the reaction over to the R.H./reductant side *or* forward direction

[1] + [1]

(ii) $KMnO_4$: Purple/violet to colourless (allow ***very*** pale pink) [1]
$K_2Cr_2O_7$ Orange to green [1]
[4]

(c) **(i)** $MnO_2 + SO_2 \longrightarrow MnSO_4$ (*or* $Mn^{2+} + SO_4^{2-}$) [1]

manganese changes/is reduced from +4 to +2 [1]
sulfur changes/is oxidised from +4 to +6 [1]

(ii) **No effect**, because H^+ does not appear in the overall equation *or* its effect on the MnO_2/Mn^{2+} change is cancelled out by its effect on the SO_2/SO_4^{2-} change [1]
[4]

(d) **(i)** $MnO_2 + 4H^+ + Sn^{2+} \longrightarrow Mn^{2+} + 2H_2O + Sn^{4+}$ [1]

(ii) $n(MnO_4^-) = 0.02 \times 18.1/1000 = 3.62 \times 10^{-4}$ mol [1]
$n(Sn^{2+}) = 3.62 \times 10^{-4} \times 5/2 = 9.05 \times 10^{-4}$ mol [1]
$n(Sn^{2+})$ that reacted with $MnO_2 = (20 - 9.05) \times 10^{-4} = 1.095 \times 10^{-3}$ mol [1]
reaction is 1:1, so this is also $n(MnO_2)$
mass of $MnO_2 = 1.095 \times 10^{-3} \times (54.9+16+16) = 0.0952$ g [1]
$\Rightarrow$ **95% – 96%;** 2 or more s.f. [1]
[6]

[Total: 16]

2 (a) (i) A molecule/ion/species with a lone pair (of electrons) *or* electron pair donor...
.... that bonds to a metal ion/transition element.... [1]

(ii) ...by means of a dative/coordinate (covalent) bond [1]
[2]

(b) (i) straight line from (0, 0.01) to point at (350, 0.0028) with all points on the line [1]

(ii) order w.r.t. $Cr(CO)_6$ is 1 **and** order w.r.t. PR_3 is zero [1]
because **(a)** $Cr(CO)_6$ graph has a constant half-life (which is 700 s)
or construction lines on graph showing this) [1]
because **(b)** PR_3 graph is a straight line (of constant slope) *or* line shows a constant rate of reaction *or* no change in rate *or* shows a linear decrease [1]

(iii) rate = $k[Cr(CO)_6]$ [1]

k = (**0.9 – 1.1) × 10^{-3}** (s^{1}) (one or more s.f.) [1]

either $rate_0 = 0.01/1020 = 9.8 \times 10^{6}$ mol sec^{1} when $[Cr(CO)_6] = 0.01$ mol dm^{3}
so $k = 9.8 \times 10^{6}/0.01 =$ **9.8×10^{-4}**
or $t_{1/2} \approx 700$ sec
$k = 0.693/700 =$ **9.9×10^{-4}**

(iv) (units of k are) **sec^{-1}** [1]

(v) N.B. the chosen mechanism must be consistent with the rate equation in **(iii)**. Thus:
either if rate = $k[Cr(CO)_6]$
mechanism **B** is consistent [1]
because it's the only mechanism that does NOT involve PR_3 in its slow/rate-determining step *or* only $Cr(CO)_6$ is involved in slow step *or* $[PR_3]$ does not affect the rate [1]

or

if rate = $k[Cr(CO)_6][PR_3]$, then
mechanism **A** or **C** or **D** is consistent [1]
because both reactants are involved in slow step [1]
[9]

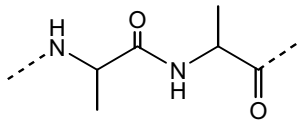
[Total: 11]

3 (a) (i) **E** is $CH_3CH(NH_2)CN$ [1]

(ii) $C_6H_5CH_2CHO$ [1]
[2]

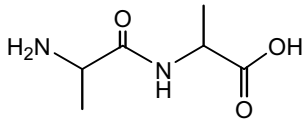
(b) (i) a polymer/polypeptide of amino acids, (joined by peptide bonds)
(allow '**chain** of amino acids' but not 'sequence': the idea of 'many' has to be conveyed)
[1]

(ii)



peptide bond shown in full (C=O) in an ala-ala fragment in a chain [1]
two repeat units [1]

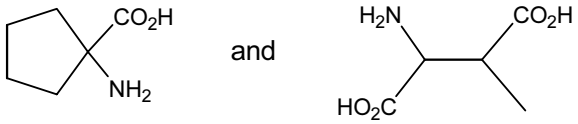
Allow peptide bond shown in full (C=O) in a dipeptide ala-ala for 1 mark



[3]

(c) (i) HC*l* *or* H_2SO_4 *or* NaOH *or* H^+ *or* OH reagents [1]
+ heat and H_2O/aq (allow H_3O^+).
If T is quoted, 80 ^oC < T < 120 ^oC. NOT warm. conditions [1]

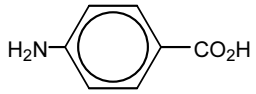
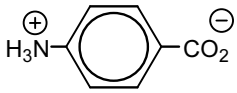
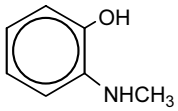
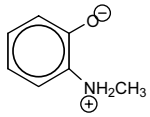
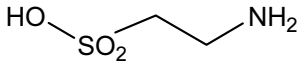
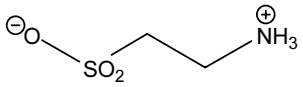
(ii)



(if a structural formula, it must have all H atoms) allow protonated or deprotonated versions [1] + [1]
[max 3]

(d) (i) $NH_3^+–CH(CH_3)–CO_2$ [1]

(ii)

compound	zwitterion
	
	
	

[3]
[4]

(e) (i) A buffer is a solution whose pH stays **fairly** constant *or* which maintains **roughly** the same pH *or* which resists/minimises changes in pH [1]
when **small/moderate** amounts of acid/H^+ or alkali/OH are added [1]

(ii) $NH_2CH(CH_3)CO_2H + H(Cl) \longrightarrow {}^+NH_3CH(CH_3)CO_2H\ (+\ Cl^-)$ [1]

(iii) blood contain $\mathbf{HCO_3^-}$ (*or* in an equation) [1]
which absorbs H^+ *or* equn $H^+ + HCO_3^- \longrightarrow H_2CO_3\ (H_2O + CO_2)$
or absorbs OH *or* equn $OH^- + HCO_3^- \longrightarrow CO_3^{2-} + H_2O$ [1]

(iv) $[CH_3CO_2Na] = 0.05\ [CH_3CO_2H] = 0.075$ [1]
pH = 4.76 + log (0.05/0.075) = **4.58** *or* **4.6** [1]
[7]

[Total: 19]

4 **(a)** $Ca(NO_3)_2 \longrightarrow CaO + 2NO_2 + ½ O_2$ [1]
[1]

(b) (down the group) nitrates become **more stable** *or* require a higher temperature to decompose [1]
as size/radius of (cat)**ion** increases *or* charge density **of ion** decreases [1]
so polarisation/distortion of **anion/nitrate** decreases [1]
[3]

(c) **(i)** $Li_2CO_3 \longrightarrow Li_2O + CO_2$ [1]

(ii) radius of Li ion/Li^+ is less than that of Na ion/Na^+ (or polarising power of M^+ is greater) [1]

(iii) Brown/orange fumes/gas would be evolved *or* glowing splint relights [1]
Since the nitrate is likely to be thermally unstable *or* decomposes (just like the carbonate) *or* the balanced equation: $2LiNO_3 \longrightarrow Li_2O + 2NO_2 + ½O_2$ [1]
[4]

[Total: 8]

5 **(a)** Alkanes are non-polar *or* have no dipole *or* C–H bonds are strong *or* C and H have similar electronegativities [1]

[1]

(b) **(i)** (free) radical substitution *or* substitution by homolytic fission [1]

(ii) initiation: $Cl_2 \longrightarrow 2Cl^{\bullet}$ [1]

propagation: $Cl^{\bullet} + C_2H_6 \longrightarrow C_2H_5^{\bullet} + HCl$

$C_2H_5^{\bullet} + Cl_2 \longrightarrow C_2H_5Cl + Cl^{\bullet}$ [1]

termination: $C_2H_5^{\bullet} + Cl^{\bullet} \longrightarrow C_2H_5Cl$

or $Cl^{\bullet} + Cl^{\bullet} \longrightarrow Cl_2$ etc [1]

all 3 names [1]

(iii)

structural formula of by-product	formed by
$CH_2Cl–CH_2Cl$ (or isomer)	**further substitution**
$CH_3CH_2CH_2CH_3$	**(termination of 2 ×) $C_2H_5^{\bullet}$**
$CH_3CH_2CH_2CH_2Cl$ (or isomer)	**substitution of C_4H_{10} by-product**

[3]

accept in the "formed by" column the formulae of radicals that will produce the compound in the "by-product" column, or the reagents, e.g. $C_4H_9^{\bullet} + Cl_2$ *or* $C_4H_9^{\bullet} + Cl^{\bullet}$ *or* $C_4H_{10} + Cl_2$ (giving $CH_3CH_2CH_2CH_2Cl$).

do not allow anything more Cl–substituted than **di**chlorobutane.

N.B. C_2H_5Cl is the **major** product, not a **by**-product, so do not allow C_2H_5Cl.

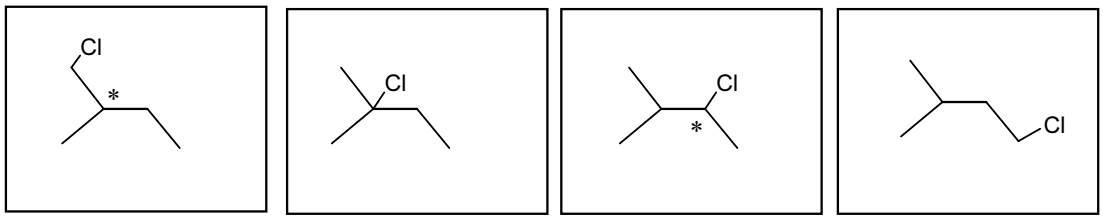
(iv) J/K = **2.3 : 1** *or* 7:3 *or* 21:9 [2]

(reason: straightforward relative rate suggests 21:1, but there are 9 primary to 1 tertiary, so divide this ratio by 9. 21/9 = 2.33)

allow [1] mark if J/K ratio is given as 21:1;

[10]

(c)



4 isomers 4 × [1]

2 chiral atoms identified correctly, even in incorrect structures [1] + [1]

[max 5]

[Total: 16]

6 (a) (i) **K**, because it is the (only) one to contain nitrogen *or* it's an amino acid
or because it contains CO_2H *or* NH groups [1]

(ii) molecule: **J,** polymer: RNA (**not** DNA) [1]
or molecule: **L,** polymer: starch, cellulose, glycogen or polysaccharide (**not** carbohydrate)
[2]

(b) (i) Covalent bonding [1]

(ii) Hydrogen bonding [1]

(iii) Ionic/electrovalent bonding *or* disulphide/–S–S– bonding *or* van der Waals' forces [1]
[3]

(c) (i) Enzymes [1]

(ii)
- change in pH
- increase in T (NOT decrease; T > 40 °C or "too high" are OK)
- addition of heavy metal ions *or* specific, e.g. Hg^{2+}, Ag^{+}. Pb^{2+} etc.

any two bullet points [1] + [1]

change in pH disrupts ionic bonds
or metal ions disrupt ionic bonds
or metal ions disrupt –S–S– bonds
or heating disrupts hydrogen bonds

any one [1]

This changes: the 3D structure *or* shape of the enzyme *or* the active site [1]
[max 4]

[Total: 9]

7 (a)

structural information	analytical technique
three-dimensional arrangement of atoms and bonds in a molecule	X-ray crystallography/diffraction
chemical environment of protons in a molecule	NMR (spectroscopy) **only**
identity of amino acids present in a polypeptide	Electrophoresis / chromatography / mass spectrometry

[1] + [1] + [1]
[3]

(b) (i) **paper chromatography;**
The components **partition** between the solvent/moving phase and the water/liquid stationary phase *or* separation relies on different solubilities (of components) in the moving solvent and the stationary water phase. [1]

(ii) **thin-layer chromatography.**
Separation depends on the differential **adsorption** of the components onto the solid particles/phase *or* Al_2O_3 *or* SiO_2. [1]
[2]

(c) (i) No. of carbon atoms present = $\frac{0.2 \times 100}{5.9 \times 1.1}$ = 3.08 hence 3 carbons [1]

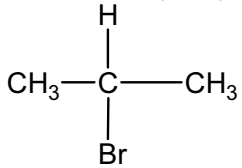
(ii) Bromine [1]

(iii) **One** bromine is present as there is only an M+2 peak / no M+4 peak *or* the M and M+2 peaks are of similar height [1]

(iv) *NMR spectrum shows a single hydrogen split by many adjacent protons and 6 protons in an identical chemical environment. This suggests...*
two $-CH_3$ groups and a lone proton attached to the central carbon atom [1]

Empirical formula of **N** is C_3H_7Br [1]

Hence **N** is $(CH_3)_2CHBr$ *or*



[1]
[6]

[Total: 11]

8 (a) (i) Soluble form would be most effective [1]

(ii) **Q**, since the 'mini-pills'/granules/powder have a larger surface area
or **P,** because it has no protective casing [1]

(iii) The gel coat stops it being broken down while passing through the upper part of the digestive system/stomach
or the gel coat is stable to stomach acid. [1]
[3]

(b) The drug is taken quickly/directly to the target
or more accurate dosing can be achieved [1]

When the drug is taken by mouth it has to pass through the stomach/intestine wall to get into the bloodstream. *or* some is digested/lost to the system [1]
[2]

(c) (i) condensation (polymerisation) [1]

(ii) hydrogen bonds *or* van der Waals' [1]

(iii) It would change the overall shape of the (drug) molecule
The 'fit' into the active site would be less effective [1] + [1]

(iv) Hydrolysis [1]
[5]

[Total: 10]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/51 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark
1 (a)	PLAN Problem	Predicts that the solubility increases (with temperature). If gave "decreasing" then ecf into sketch and do not mark explanation. KNO_3 needs energy to dissolve OR supplying heat or energy or increasing temperature will promote the endothermic change/ reaction. Any graph showing an increasing solubility with temperature (curve or straight line) that reflects the prediction. Do not accept a concave curve that becomes vertical. Accept a convex curve (accept with a max or an end decline). There can be a plateau in solubility. Have solubility on the *y* axis and temperature on the *x* axis. Ignore units unless the unit is the label. If gave "decreasing" above then ecf into sketch. If the prediction is irrelevant e.g. rate then can mark sketch as stand alone	[1] [1] [1]
(b)	PLAN Problem	**(i)** Temperature as the independent variable. **(ii)** Solubility as the dependent variable. Has to be a double quantity, not just mass or amount of solute. Ecf "concentration" if given as *y*-axis in sketch.	[1] [1]

(c)	PLAN Methods	There are four different approaches, all of which share the first five marking points. Use 7 number labelled ticks and crosses for these points. **(i)** At least 5 experiments. **(ii)** Uses a range of at least 40°C. **(iii)** Pilot run to choose relative amounts of materials. **(iv)** Mass by balance. Water by measuring cylinder/pipette/ burette or mass of water by balance. **(v)** stirs Alternate 1 **(vi)** Heat mixture to dissolve all the solute. **(vii)** Cool and measure the temperature at which first crystals appear. OR Alternate 2 **(vi)** Heats mixture to a particular temperature. **(vii)** Filters the solution (not cooled or decanted) and weighs the residue. OR Alternate 3 **(vi)** Heats mixture to a particular temperature. **(vii)** filters the solution (not cooled or decanted) and evaporates the filtrate and weighs solid. OR Alternate 4 **(vi)** Heats mixture to dissolve the solute. **(vii)** Records temperature at which the solute dissolves.	[1] [1] [1] [1] [1] [1] [1]
(d)	PLAN Methods	Reference to 'hot' apparatus, not Bunsen or water with Handle with tongs/heat resistant gloves/cool before handling	[1]

(e)	PLAN Methods	**1(c)(i)** & **(ii)** could award here. Mass of solid dissolved; volume/mass of water; solubility; temperature (solution) and units. Only accept a final temperature if it relates to the temperature of solution. All five correct 2 marks; Three or four correct (one/two errors) 1 mark; Two or less correct (more than two errors) zero.	[2]
	Total		**[15]**

Question	Sections	Indicative material	Mark
2 (a)	ACE Data	Log_{10}(rate) or Log_{10}(1/time) or Log_{10}(1/t). One of these labels also serves as expression, full column no units. Accept log with no base. Reciprocal absolute temperature or reciprocal Kelvin temperature or 1/T (not temp etc.). One of these labels also serves as expression, full column with unit, K^{1}. Don't accept $1/T \times 10^{3}/K^{1}$ but $/10^{3}K^{1}$ OK Data in both columns above to 3 sig figs and correct, allow 2 errors. Allow salvage mark for rate column if ALL correct. A heading of 1/time or 1/t or 1/C also serves as expression.	[1] [1] [1]
(b)	ACE Data	Unambiguously labelled axes. 1/T on the *x*-axis and log_{10}(rate) on the *y* axis AND appropriate scaling. Ignore units unless it is the label. Correctly plotted points. Ecf incorrectly calculated data. All 10 points need to be plotted. Check points 3 & 7 and 1 & 10 and any others off the line. Line of best fit. Allow plot and line marks if other axes used.	[1] [1] [1]

(c)	ACE Evaluation	Allow the candidate to select up to five anomalies which must include that furthest from the line. This mark is available if other axes used. The data has two anomalies, Points 3 & 7. Point 3, Timed to past opacity (not late stopping the clock alone), or solutions not equilibrated with water bath temperature or clock started early. Point 7, Timed to prior to opacity (not early stopping the clock alone), or clock started late. Give a rescue mark if both correct anomalies present but not linked to their points. These last two marks not available if other axes used.	[1] [1] [1]
(d)	ACE Evaluation	Either no repeats OR five or more points not on line hence unreliable OR most points on line OR points produce straight line hence reliable. This mark not available if other axes used.	[1]
(e)	ACE Data	Has construction lines on the plot. States intercept readings from them. (Could be to data points if the line and construction is to that point. Powers of 10 (e.g. × 10 ^{3}) must be included if necessary) then calculates the slope (around –1050). Slope is $(y_1 - y_2)/(x_1 - x_2)$. The sign of the gradient must be correct from the sign produced from the intercept calculations. Allow these marks if other axes used.	[1] [1]
(f)	ACE Conclusions	Correct calculation. Any calculation that has slope above multiplied by 19 i.e. $-E_A$ = slope × 19. Or slope = $-E_A/19$. Ignore units. Also accept that calculation subsequently divided by 1000 i.e. about 19950 or 19.95. T is not in this calculation. Allow this mark for other plots.	[1]
(g)	ACE Conclusions	Increased K.E/energy/speed. More collisions/unit time or more frequent collisions or more chance of collisions or more energetic collisions or more collisions exceeding activation energy or more successful collisions or more effective collisions. NOT just more collisions.	[1] [1]
	Total		**[15]**

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/52 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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UNIVERSITY of CAMBRIDGE
International Examinations

Question	Sections	Indicative material	Mark
1 (a)	PLAN Problem	Predicts that the solubility increases (with temperature). If gave "decreasing" then ecf into sketch and do not mark explanation. KNO_3 needs energy to dissolve OR supplying heat or energy or increasing temperature will promote the endothermic change/ reaction. Any graph showing an increasing solubility with temperature (curve or straight line) that reflects the prediction. Do not accept a concave curve that becomes vertical. Accept a convex curve (accept with a max or an end decline). There can be a plateau in solubility. Have solubility on the *y* axis and temperature on the *x* axis. Ignore units unless the unit is the label. If gave "decreasing" above then ecf into sketch. If the prediction is irrelevant e.g. rate then can mark sketch as stand alone	[1] [1] [1]
(b)	PLAN Problem	**(i)** Temperature as the independent variable. **(ii)** Solubility as the dependent variable. Has to be a double quantity, not just mass or amount of solute. Ecf "concentration" if given as *y*-axis in sketch.	[1] [1]

(c)	PLAN Methods	There are four different approaches, all of which share the first five marking points. Use 7 number labelled ticks and crosses for these points. **(i)** At least 5 experiments. **(ii)** Uses a range of at least 40°C. **(iii)** Pilot run to choose relative amounts of materials. **(iv)** Mass by balance. Water by measuring cylinder/pipette/ burette or mass of water by balance. **(v)** stirs Alternate 1 **(vi)** Heat mixture to dissolve all the solute. **(vii)** Cool and measure the temperature at which first crystals appear. OR Alternate 2 **(vi)** Heats mixture to a particular temperature. **(vii)** Filters the solution (not cooled or decanted) and weighs the residue. OR Alternate 3 **(vi)** Heats mixture to a particular temperature. **(vii)** filters the solution (not cooled or decanted) and evaporates the filtrate and weighs solid. OR Alternate 4 **(vi)** Heats mixture to dissolve the solute. **(vii)** Records temperature at which the solute dissolves.	[1] [1] [1] [1] [1] [1] [1]
(d)	PLAN Methods	Reference to 'hot' apparatus, not Bunsen or water with Handle with tongs/heat resistant gloves/cool before handling	[1]

(e)	PLAN Methods	**1(c)(i)** & **(ii)** could award here. Mass of solid dissolved; volume/mass of water; solubility; temperature (solution) and units. Only accept a final temperature if it relates to the temperature of solution. All five correct 2 marks; Three or four correct (one/two errors) 1 mark; Two or less correct (more than two errors) zero.	[2]
	Total		**[15]**

Question	Sections	Indicative material	Mark
2 (a)	ACE Data	Log_{10}(rate) or Log_{10}(1/time) or Log_{10}(1/t). One of these labels also serves as expression, full column no units. Accept log with no base. Reciprocal absolute temperature or reciprocal Kelvin temperature or 1/T (not temp etc.). One of these labels also serves as expression, full column with unit, K^{1}. Don't accept $1/T \times 10^{3}/K^{1}$ but $/10^{3}K^{1}$ OK Data in both columns above to 3 sig figs and correct, allow 2 errors. Allow salvage mark for rate column if ALL correct. A heading of 1/time or 1/t or 1/C also serves as expression.	[1] [1] [1]
(b)	ACE Data	Unambiguously labelled axes. 1/T on the *x*-axis and log_{10}(rate) on the *y* axis AND appropriate scaling. Ignore units unless it is the label. Correctly plotted points. Ecf incorrectly calculated data. All 10 points need to be plotted. Check points 3 & 7 and 1 & 10 and any others off the line. Line of best fit. Allow plot and line marks if other axes used.	[1] [1] [1]

(c)	ACE Evaluation	Allow the candidate to select up to five anomalies which must include that furthest from the line. This mark is available if other axes used. The data has two anomalies, Points 3 & 7. Point 3, Timed to past opacity (not late stopping the clock alone), or solutions not equilibrated with water bath temperature or clock started early. Point 7, Timed to prior to opacity (not early stopping the clock alone), or clock started late. Give a rescue mark if both correct anomalies present but not linked to their points. These last two marks not available if other axes used.	[1] [1] [1]
(d)	ACE Evaluation	Either no repeats OR five or more points not on line hence unreliable OR most points on line OR points produce straight line hence reliable. This mark not available if other axes used.	[1]
(e)	ACE Data	Has construction lines on the plot. States intercept readings from them. (Could be to data points if the line and construction is to that point. Powers of 10 (e.g. × 10 ^{3}) must be included if necessary) then calculates the slope (around –1050). Slope is $(y_1 - y_2)/(x_1 - x_2)$. The sign of the gradient must be correct from the sign produced from the intercept calculations. Allow these marks if other axes used.	[1] [1]
(f)	ACE Conclusions	Correct calculation. Any calculation that has slope above multiplied by 19 i.e. $-E_A$ = slope × 19. Or slope = $-E_A/19$. Ignore units. Also accept that calculation subsequently divided by 1000 i.e. about 19950 or 19.95. T is not in this calculation. Allow this mark for other plots.	[1]
(g)	ACE Conclusions	Increased K.E/energy/speed. More collisions/unit time or more frequent collisions or more chance of collisions or more energetic collisions or more collisions exceeding activation energy or more successful collisions or more effective collisions. NOT just more collisions.	[1] [1]
	Total		**[15]**

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper for the guidance of teachers

9701 CHEMISTRY

9701/53 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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Question	Sections	Indicative material	Mark
1 (a)	PLAN Problem	Predicts that the rate of effusion decreases as the M_r increases. If candidates gave 'increasing' then ecf into sketch. **(i)** Correctly labelled axes with rate of effusion on the *y*-axis and M_r on the *x*-axis. **(ii)** Any graph showing a decreasing rate of effusion with increasing M_r (curve or straight line). This curve should not start vertical or show a positive gradient at any stage. It should not touch either axis.	[1] [1] [1]
(b)	PLAN Problem	**(i)** M_r as the independent variable. **(ii)** Rate of effusion/time as the dependent variable.	[1] [1]
(c)	PLAN Methods	**(i)** Flush out the syringe with the gas under test at least once before filling. Accept gas removal by vacuum pump. **(ii)** Starts the descent of the piston above the start volume to ensure constant speed. (Free movement, not pushed to start mark.) **(iii)** Uses the same volume for all the gasses or measures the time between the same two volume marks. Alternatively, candidates may record volume effused over a fixed time for all gases. Table in **1(e)** will change slightly in this case. **(iv)** Constant/same temperature for all experiments. **(v)** Ensures that the syringe is vertical or at the same angle throughout. **(vi)** Repeats the procedure (to obtain means). These may be referred to in the table in **1(e)**.	[1] [1] [1] [1] [1] [1]
(d)	PLAN Methods	Reference to flammability of hydrogen/butane or the poisonous nature of chlorine. Accept explosive nature of hydrogen or butane. Must name the gas. Keep away from flames/use a fume cupboard or gas mask (not just mask). This mark is conditional on naming a gas correctly above. If a candidate only suggests that <u>some</u> gases are poisonous and then suggests a fume cupboard is necessary do not give any marks. If, for example, a candidate suggests that hydrogen, oxygen and butane are flammable, do not award the first mark but reference to no naked flames etc would be worth the second mark. Mark similarly if candidate suggests chlorine and carbon dioxide or butane are poisonous.	[1] [1]

(e)	PLAN Methods	Name /formulae of all the gases; correct M_rs; effusion time (or effusion volume for alternative method); rate of effusion; with relevant units. If an incorrect formula is given, ecf for M_r. All five correct 2 marks; One/two errors, three or four correct 1 mark; More than two errors zero mark.	[2]
	Total		**[15]**

Question	Sections	Indicative material	Mark
2 (a)	ACE Data	Moles of oxygen; e.g. D/16 ; no units. Moles of lead; e.g. E/207; no units. There must be full columns of data with these two headings. Do not accept any incorrect units in these headings. Can accept A_r oxygen etc., not M_r, instead of numerical values. Correct data for moles of lead and oxygen (allow 2 errors). Ecf if 32 used for M_r oxygen. A salvage mark can be awarded for one completely correct mass column, i.e. heading, expression, units and data.	[1] [1] [1]
(b)	ACE Data	Unambiguously labelled axes/Appropriate scaling. Moles of lead or moles of oxygen can be on either axis. Correctly plotted points. All 10 points need to be plotted. Line of best fit which should be drawn to the origin. Lines should be straight with no kinks. If 'non-plots' are given, e.g. moles lead oxide vs moles lead, plotting marks are still available. Candidates cannot access marks in **2(c)** or **2(d)** but can access marks in **2(e)**.	[1] [1] [1]
(c)	ACE Evaluation	Anomalies identified. Allow candidates to select up to 5 anomalous points which must include that furthest from the line. Correct explanation for the first anomaly. Correct explanation for the second anomaly. Point 4, incomplete reduction (to lead side of line). Point 8, material carried away by stream of hydrogen (to oxygen side of line). If two correct explanations are given but not allocated to specific points, give 1 mark.	[1] [1] [1]

(d)	ACE Evaluation	Either no repeats/most points not on the line hence unreliable. Most points on or close to the line hence reliable, not just a straight line is produced.	[1]
(e)	ACE Data	Construction lines present. Takes intercept readings from the graph. Calculates the slope correctly using intercept readings. Gradient can be either $(y_1 - y_2)/(x_1 - x_2)$ or $(y_2 - y_1)/(x_2 - x_1)$.	[1] [1]
(f)	ACE Conclusions	Line is the ratio of oxygen to lead or vice versa. Calculation to determine the formula, i.e. gives the ratio of atoms commensurate with the answer in **2(e)**. States formula. Pb_3O_4 would usually mean that the last 2 marks are awarded automatically. Ecf an over-approximation of the ratio.	[1] [1] [1]
	Total		**[15]**