

MARK SCHEME for the May/June 2013 series

9701 CHEMISTRY

9701/21

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

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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	GCE AS/A LEVEL – May/June 2013	9701	21

- 1 (a) (i) $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ (1)
- $(\text{NH}_4)_2\text{SO}_4 + 2\text{NaOH} \rightarrow 2\text{NH}_3 + \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ (1)
- allow ionic equations in each case
- (ii) $n(\text{NaOH}) = n(\text{HCl}) = \frac{39.2 \times 2.00}{1000} = 0.0784$ (1)
- (iii) $n(\text{NaOH}) = n(\text{HCl}) = \frac{29.5 \times 2.00}{1000} = 0.059$ (1)
- (iv) $n(\text{NaOH}) = 0.0784 - 0.059 = 0.0194$ (1)
- (v) $n[(\text{NH}_4)_2\text{SO}_4] = \frac{0.0194}{2} = 9.7 \times 10^{-3}$ (1)
- (vi) mass of $(\text{NH}_4)_2\text{SO}_4 = 9.7 \times 10^{-3} \times 132.1 = 1.2814 \text{ g}$ (1)
- (vii) % of $(\text{NH}_4)_2\text{SO}_4 = \frac{1.2814 \times 100}{2.96} = 43.30405405 = 43.3$
 give one mark for the correct expression (1)
 give one mark for answer given as 43.3 – i.e. to 3 sig. fig. (1)
 allow ecf where appropriate [9]
- (b) fertiliser in the river causes
 excessive growth of aquatic plants/algae **or** algal bloom (1)
 when plants and algae die O_2 is used up **or** fish or aquatic life die (1) [2]
- (c) manufacture of HNO_3 **or** explosives **or** nylon **or**
 as a cleaning agent **or** as a refrigerant
not detergent (1) [1]

[Total:12]

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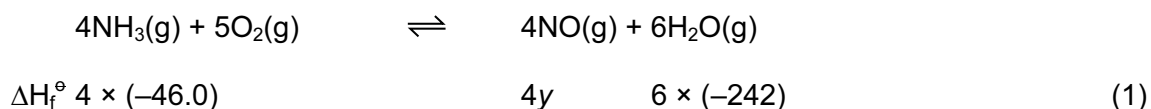
2 (a) $K_p = \frac{p(\text{NO})^4 p(\text{H}_2\text{O})^6}{p(\text{NH}_3)^4 p(\text{O}_2)^5}$ (1)

atmospheres **or** Pa **or** kPa (1)
allow ecf on incorrect powers [2]

(b) (i) **increasing temperature**
yield of NO is decreased **or** reaction moves to LHS (1)
forward reaction is exothermic (1)

(ii) **decreasing the pressure**
yield of NO is increased **or** reaction moves to RHS (1)
more moles/molecules of gas on RHS **or**
fewer moles/molecules of gas on LHS (1) [4]

(c) let $\Delta H_f^\ominus$ for NO be $y \text{ kJ mol}^{-1}$



$$\Delta H_{\text{reaction}}^\ominus = 4y + [6 \times (-242)] - [4 \times (-46.0)] \qquad (1)$$

$$= 4y - 1452 + 184$$

$\Delta H_{\text{reaction}}^\ominus$ is -906 kJ mol^{-1} so (1)
 $4y = -906 + 1452 - 184 = 362$

whence $y = \Delta H_f^\ominus$ for NO = $+90.5 \text{ kJ mol}^{-1}$ (1) [4]
+ sign is required

[Total: 10]

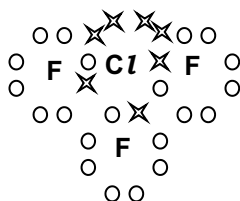
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3 (a) penalise (–1) for names of elements

- (i) Na **or** K **or** Li (1)
- (ii) S **or** C **or** N **or** P (1)
- (iii) K (1)
- (iv) C (1)
- (v) Cl (1)
- (vi) Al **or** Si (1) [6]

- (b) (i) Al_2O_3 **or** SiO_2 (1)
- (ii) Na_2O (1)
- (iii) P_2O_3 **or** P_4O_6 **and** P_2O_5 **or** P_4O_{10} **or** SO_2 **and** SO_3 (1+1)
- (iv) Al_2O_3 (1) [5]

(c) (i)



- 3 bonding pairs **and**
 2 lone pairs around Cl atom (1)
 3 lone pairs on **each** of the F atoms (1)

(ii) **either**

referring to van der Waals' forces in BrF_3

- van der Waals' **or**
 intermolecular forces are greater/stronger (1)
 because there are more electrons in BrF_3 than in $CClF_3$ (1)

OR referring to permanent dipoles

- permanent dipole **or** intermolecular forces are stronger/greater in BrF_3 (1)
 because BrF_3 has a larger permanent dipole than $CClF_3$

OR because difference in electronegativity is larger between Br and F than between Cl and F (1)

part (ii) has a maximum of 2 marks (max 2) [4]

[Total: 15]

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4 Types of reaction used must come from the list in the question.

organic reaction	type of reaction	reagent(s)
CH ₃ CH ₂ CH ₂ CH ₂ Br → CH ₃ CH ₂ CH ₂ CH ₂ NH ₂	nucleophilic (1) substitution (1)	NH ₃ (1)
CH ₃ CH ₂ CH ₂ CH ₂ OH → BrCH ₂ CH ₂ CH ₂ CH ₂ OH	free radical (1) substitution (1)	Br ₂ or Br ₂ in an organic solvent (1) not Br ₂ (aq)
CH ₃ COCH ₃ → CH ₃ C(OH)(CN)CH ₃	nucleophilic (1) addition (1)	HCN or HCN and CN ⁻ or NaCN/KCN + H ⁺ (1)
CH ₃ CH(OH)CH ₂ CH ₃ → CH ₃ CH=CHCH ₃	elimination (1) not dehydration	conc. H ₂ SO ₄ or P ₄ O ₁₀ or Al ₂ O ₃ or H ₃ PO ₄ (1)

[Total: 11]

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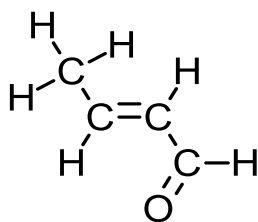
5 (a)

reaction	reagent	product
A	Br ₂ in an inert organic solvent	CH ₃ CHBrCHBrCHO
B	PCl ₃	NO REACTION
C	H ₂ and Ni catalyst	CH ₃ CH ₂ CH ₂ CH ₂ OH
D	NaBH ₄	CH ₃ CH=CHCH ₂ OH
E	K ₂ Cr ₂ O ₇ /H ⁺	CH ₃ CH=CHCO ₂ H

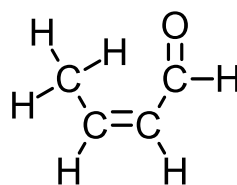
one mark for each correct answer

[5]

(b)



trans or E



cis or Z

two correct structures

(1)

both correctly labelled

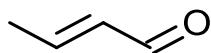
(1)

correctly displayed -CHO group

(1) [3]

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(c)



(1) [1]

(d) (i) $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$

(1)

(ii) $\text{CH}_3\text{CO}_2\text{H}$
 $\text{HO}_2\text{CCO}_2\text{H}$

(1)

(1) [3]

allow ecf on candidate's answer to E in (a)

[Total: 12]

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- 1 (a) a base is a proton acceptor **or**
a lone pair donor (1)
a weak base is not fully ionised (1)
e.g. $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$ **or**
 $\text{B} + \text{H}^+ \rightleftharpoons \text{BH}^+$ **or** equivalent
 $\rightleftharpoons$ is necessary (1) [3]
- (b) (i) **stated** pressure greater than 1 atm up to 5 atm (1)
stated temperature 400 to 500 °C (1)
named catalyst V_2O_5 /vanadium(V) oxide (1)
- (ii) SO_3 is dissolved in concentrated H_2SO_4
and then diluted with water
not ' SO_3 dissolved in water' as the only statement (1) [4]
- (c) (i) **with concentrated sulfuric acid**
 $\text{ClCH}_2\text{CH=CHCl}$ (1)
- with ammonia**
 $\text{H}_2\text{NCH}_2\text{CH(OH)CH}_2\text{NH}_2$ (1)
- (ii) nucleophilic (1)
substitution (1) [4]

[Total: 11]

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- 2 (a) (i) $n(\text{H}_2\text{SO}_4) = \frac{25.0 \times 1.00}{1000} = 0.025 \text{ mol}$ (1)
- (ii) $n(\text{NaOH}) = \frac{16.2 \times 2.00}{1000} = 0.0324 \text{ mol}$ (1)
- (iii) $n(\text{H}_2\text{SO}_4) \text{ reacting with NaOH} = \frac{0.0324}{2} = 0.0162 \text{ mol}$ (1)
- (iv) $n(\text{H}_2\text{SO}_4) \text{ reacting with NH}_3 = 0.025 - 0.0162 = 0.0088 \text{ mol}$ (1)
- (v) $n(\text{NH}_3) \text{ reacting with H}_2\text{SO}_4 = 2 \times 0.0088 = 0.0176 \text{ mol}$ (1)
- (vi) $n(\text{NaNO}_3) \text{ reacting} = n(\text{NH}_3) \text{ produced} = 0.0176 \text{ mol}$ (1)
- (vii) mass of NaNO_3 that reacted = $0.0176 \times 85 = 1.496 \text{ g}$ (1)
- (viii) $\% \text{ of NaNO}_3 = \frac{1.496 \times 100}{1.64} = 91.2195122 = 91.2$
- give one mark for the correct expression (1)
- give one mark for answer given as 91.2 – i.e to 3 sig. fig. (1)
- allow ecf where appropriate

[9]

- (b) NaNO_3 +5 and NH_3 -3 both required (1) [1]

[Total: 10]

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3 (a) penalise (-1) the use of names of elements or formulae of compounds

- (i) Ca (1)
- (ii) O or N or C (1)
- (iii) C or N or S or F or Cl or Br (1)
- (iv) Si or Ge or B (1)
- (v) Al or Si or P or S or H (1)
- (vi) Al (1) [6]

(b) (i)

element	Na	Mg	Al	Si	P	S
oxide	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅ /P ₄ O ₁₀ or P ₂ O ₃ /P ₄ O ₆	SO ₂
flame	yellow or orange	white	white	white	white or yellow	blue

formula of oxide (1)
colour of flame (1)

(ii)

chloride	NaCl	MgCl ₂	AlCl ₃ or Al ₂ Cl ₆	SiCl ₄	PCl ₃ or PCl ₅	SCl ₂ or S ₂ Cl ₂
pH	7	6.5 to 6.9	1 to 4			

formula of chloride (1)
pH of solution formed (1) [4]

(c) (i)



(1)

- (ii) intermolecular forces/van der Waals' forces are stronger or greater in ICl (1)
ICl has most electrons or has the largest permanent dipole (1)

- (iii) ICl (1)
greatest difference in electronegativity is between I and Cl (1) [5]

[Total: 15]

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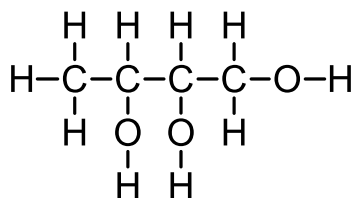
4 (a)

A	Br ₂ in an inert organic solvent	CH ₃ CHBrCHBrCH ₂ OH
B	PCl ₅	CH ₃ CH=CHCH ₂ Cl
C	H ₂ and Ni catalyst	CH ₃ CH ₂ CH ₂ CH ₂ OH
D	NaBH ₄	NO REACTION
E	K ₂ Cr ₂ O ₇ /H ⁺ , heat under reflux	CH ₃ CH=CHCO ₂ H

give one mark for each correct answer

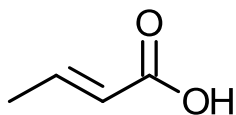
(5 × 1) [5]

(b)



(1) [1]

(c)



correct C₄ with C=C in position 2

accept *cis* form

correctly shown –CO₂H

allow ecf on candidate's answer to E in (a)

(1)

(1)

[2]

Page 6	Mark Scheme	Syllabus	Paper
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- | (d) (i) reagent | observation | |
|--|--|---------|
| 2,4-dinitrophenylhydrazine | red/orange ppt. | |
| Tollens' reagent | silver mirror or
grey ppt. or
black ppt. | |
| Fehling's reagent | brick red ppt. | |
| correct reagent | | (1) |
| observation | | (1) |
| (ii) reduction or nucleophilic addition | | (1) [3] |
-
- (e) $C : H : O = \frac{73.7}{12} : \frac{12.3}{1} : \frac{14.0}{16}$
- $= 6.14 : 12.3 : 0.875$ (1)
- $= 7.01 : 14.1 : 1$
- gives $C_7H_{14}O$
- formula must be given (1) [2]

[Total: 13]

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5 (a) $C_4H_8O_2$ (1) [1]

(b)

$HCO_2CH_2CH_2CH_3$ W	$HCO_2CH(CH_3)_2$ X
$CH_3CO_2CH_2CH_3$ Y	$CH_3CH_2CO_2CH_3$ Z

give one mark for each correct answer (4 × 1) [4]

(c) (i) $—CHO$ **or** aldehyde absent (1)
(ii) $>CO$ **or** carbonyl absent (1)
(iii) $—CO_2H$ **or** carboxylic acid present (1) [3]

(d) (i) CH_3CO_2H **or** ethanoic acid (1)
(ii) **Y** above (1) [2]

(e) none – no chiral carbon atoms present (1) [1]

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1 (a) (i)



S atom has 6 **and** C atom has 4 electrons (1)

S=C double bonds (4 electrons) clearly shown (1)

(ii) linear **and** 180° (1) [3]

(b) (i) $\text{CS}_2 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{SO}_2$ (1)

(ii) enthalpy change when 1 mol of a substance (1)

is burnt in an excess of oxygen/air

or is completely combusted

under standard conditions (1) [3]

(c)

$$\begin{array}{rclcl}
 \text{CS}_2 & + & 3\text{O}_2 & \rightarrow & \text{CO}_2 & + & 2\text{SO}_2 & & \\
 \Delta H_f^\ominus / \text{kJ mol}^{-1} & & x & & -395 & & 2(-298) & & (1) \\
 \Delta H_{\text{reaction}} = -395 + 2(-298) - x = -1110 \text{ kJ mol}^{-1} & & & & & & & & (1) \\
 \text{gives } x = -395 + (-596) + 1110 = +119 \text{ kJ mol}^{-1} & & & & & & & & (1) [3]
 \end{array}$$

(d) (i) $\text{CS}_2 + 2\text{NO} \rightarrow \text{CO}_2 + 2\text{S} + \text{N}_2$
or
 $\text{CS}_2 + 2\text{NO} \rightarrow \text{CO} + 2\text{S} + \text{N}_2\text{O}$

correct products (1)

correct equation (1)

(ii) from -2 to 0 **both** required (1) [3]

[Total: 12]

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- 2 (a) (i) if the conditions of a system in equilibrium are changed (1)
the position of equilibrium moves so as to reduce that change (1) [2]
- (ii) lower temperature (1)
because the forward reaction is exothermic (1)
higher pressure (1)
because the forward reaction shows a reduction in volume
or
there are fewer molecules/moles on RHS of equilibrium (1) [4]

(b)

	CO ₂	+	H ₂	⇌	CO	+	H ₂ O	
initial moles	0.70		0.70		0.30		0.30	
equil. moles	(0.70-x)		(0.70-x)		(0.30+x)		(0.30+x)	(1)
equil. concn.	$\frac{(0.70-x)}{1}$		$\frac{(0.70-x)}{1}$		$\frac{(0.30+x)}{1}$		$\frac{(0.30+x)}{1}$	

$K_c = \frac{(0.30+x)^2}{(0.70-x)^2} = 1.44$ (1)

gives $x = 0.25$ (1)
at equilibrium,
 $n(\text{CO}_2) = n(\text{H}_2) = 0.70 - 0.25 = 0.45$ moles
and
 $n(\text{CO}) = n(\text{H}_2\text{O}) = 0.3 + 0.25 = 0.55$ moles (1) [4]

[Total: 10]

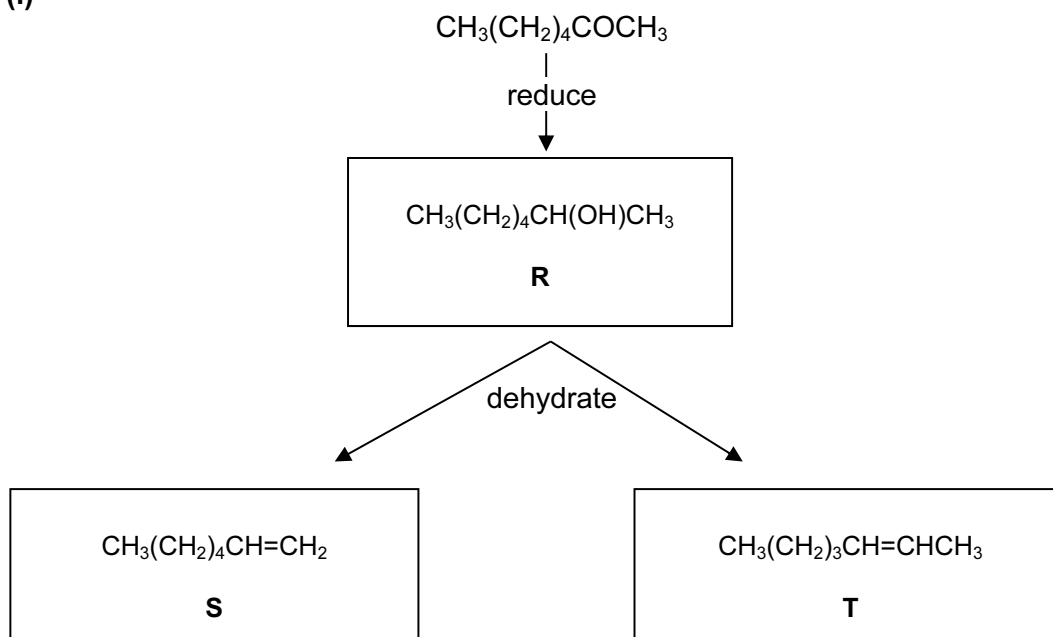
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- 3 (a) (i) He or Ne or Ar or Kr (1)
- (ii) P or As (1)
- (iii) Br (1)
- (iv) Na allow Ar (1)
- (v) Si (1)
- (vi) P allow Si (1)
- (vii) Cl or F or Br (1) [7]
- (b) (i) any **two** from P_4O_6 , SO_2 and Cl_2O_7 (1+1)
- (ii) Al_2O_3 or SiO_2 (1)
- (iii) $MgSO_3$ (1) [4]
- (c) (i) Si is giant molecular/giant covalent or
P, S, and Cl are simple molecular (1)
- (ii) the molecules are S_8 , P_4 , Cl_2 (1)
- larger molecules have more electrons (1)
- and hence greater van der Waals' forces (1) [4]

[Total: 15]

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4 (a) (i)



one mark for each correct compound, **R**, **S** and **T**

allow correct *cis* **and** *trans* versions of compound **T** for 2 marks (3 × 1)

(ii) reduction

NaBH_4 **or** LiAlH_4 **or** H_2/Ni **or** $\text{Na}/\text{C}_2\text{H}_5\text{OH}$ (1)

dehydration

$\text{P}_4\text{O}_{10}/\text{P}_2\text{O}_5$ **or** H_3PO_4 **or** conc. H_2SO_4 **or** Al_2O_3 (1) [5]

(b)

Tollens' reagent	NO REACTION
HCN	$\begin{array}{c} \text{CH}_3(\text{CH}_2)_4\text{C}(\text{OH})\text{CH}_3 \\ \\ \text{CN} \end{array}$
$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$	NO REACTION

one mark for each correct answer (3 × 1) [3]

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(c) Na_2CO_3 or NaHCO_3 effervescence/colourless gas

or

Na colourless gas

or

$\text{PCl}_3/\text{PCl}_5$ etc. steamy fumes

or

$\text{C}_2\text{H}_5\text{OH}/\text{conc. H}_2\text{SO}_4$ sweet smell of ester

or

$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ orange solution becomes green

correct reagent

(1)

correct observation

(1) [2]

[Total: 10]

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- 5 (a) (i) $\text{CH}_2=\text{CHCO}_2\text{H}$ (1)
- (ii) $\text{BrCH}_2\text{CHBrCH}_2\text{OH}$ (1)
- (iii) product is $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$
- correct addition across $>\text{C}=\text{C}<$ (1)
- original $-\text{CH}_2\text{OH}$ remains (1)
- (iv) $\text{HO}_2\text{CCO}_2\text{H}$ (1) [5]
- (b) (i) nucleophilic substitution (1)
- (ii) oxidation (1) [2]
- (c) (i) **step I**
- H_2 (1)
- heat with Ni catalyst (1)
- step II**
- acidified $\text{K}_2\text{Cr}_2\text{O}_7$ (1)
- heat **or** distil off product (1)
- (ii) structural isomerism
- or**
- functional group isomerism (1) [5]
- (d) **both** oxidation **and** reduction have occurred **or**
- disproportionation has taken place (1) [1]

[Total: 13]