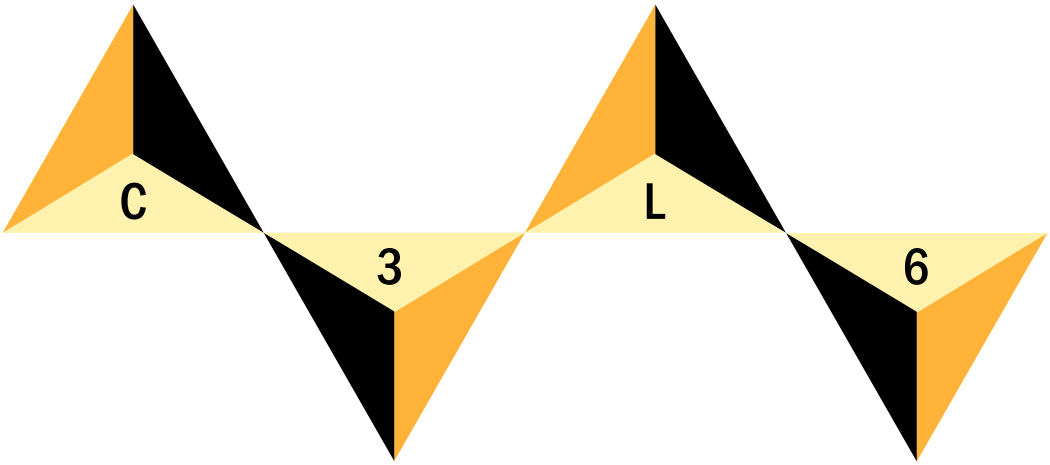


Cambridge Chemistry Challenge Lower 6th

June 2014

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	p8	p9	Total
mark	6	10	6	6	7	9	9	7	**60**

leave blank

1(a)(i) **oxidation states:**

Be	H	Si	O
+2	+1	+4	−2

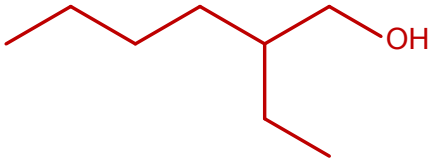
✓✓ 2

[half mark each; do not penalise if + sign missing]

(a)(ii)

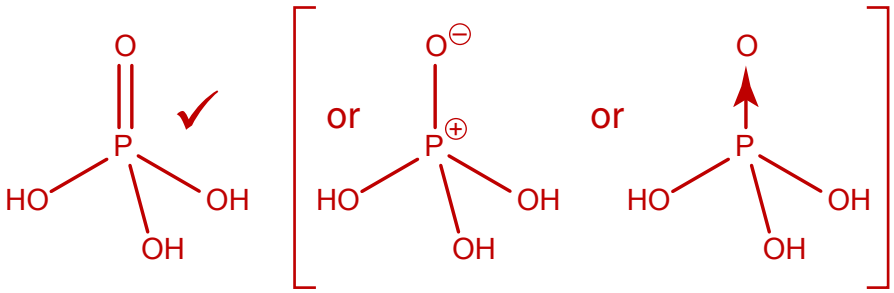
$(4 \times 2) + (2 \times 1) + (2 \times 4) = 2x \quad \therefore x = 9$ ✓ 1

(b)(i) **structure of 2-ethylhexan-1-ol:**



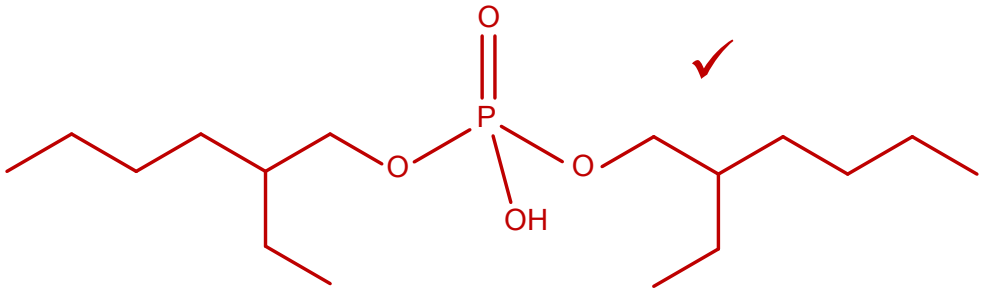
✓ 1

(b)(ii) **structure of phosphoric(V) acid:**



✓ 1

(b)(iii) **structure of DEHPA:**



✓ 1

[alternative phosphate structures acceptable as before]

Page total 6

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1(c)(i)

$$3(NH_4)_4Be(CO_3)_3 \longrightarrow Be(OH)_2{\cdot}2BeCO_3 + 12NH_3 + 7CO_2 + 5H_2O$$ ✓✓

[2 marks if totally correct; 0 if anything wrong]

2

(c)(ii)

$$Be(OH)_2{\cdot}2BeCO_3 + 2H_2O \longrightarrow 3Be(OH)_2 + 2CO_2$$ ✓

1

(d) standard enthalpy change:

$$BeF_2(s) + Mg(s) \xrightarrow{\Delta H^\circ} Be(s) + 2MgF_2(s)$$

-1010 kJ mol^{-1} ↖ ↗ -1124 kJ mol^{-1}

$$Be(s) + 2F_2 + Mg(s)$$

$\Delta H^\circ = -(-1010) - 1124 = -114$ kJ mol^{-1} ✓✓

[1 mark if correct number but wrong sign]

2

(e)(i) molar volume of Be

1.85 g Be ≡ 1 cm^3 ≡ 10^{-6} m^3

$\therefore$ 1 g Be ≡ $\frac{10^{-6}}{1.85}$ m^3

$\therefore$ 1 mol Be ≡ 9.01 g

≡ $\frac{9.01\times10^{-6}}{1.85}$ m^3

$= 4.87\times10^{-6}$ m^3 mol^{-1} ✓

molar volume of Ca

1.55 g Ca ≡ 1 cm^3 ≡ 10^{-6} m^3

$\therefore$ 1 g Ca ≡ $\frac{10^{-6}}{1.55}$ m^3

$\therefore$ 1 mol Ca ≡ 40.08 g

≡ $\frac{40.08\times10^{-6}}{1.55}$ m^3

$= 2.59\times10^{-5}$ m^3 mol^{-1} ✓

2

(e)(ii) *r* (Ca) / *r* (Be)

molar volume $\propto$ atomic volume $\propto r^3$

$$\frac{r(Ca)}{r(Be)} = \sqrt[3]{\frac{40.08}{1.55}\times\frac{1.85}{9.01}} = 1.74$$ ✓✓✓

[2 marks if inverse i.e. 0.573 ; otherwise zero]

3

Page total 10

leave blank

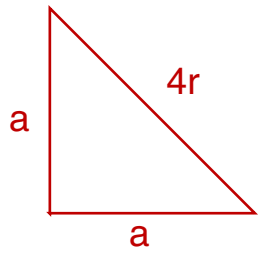
1(f)(i) number of atoms in volume a^3

8 at corners (1/8 each)
+ 6 at faces (1/2 each)
total (8 x 1/8) + (6 x 1/2) = 4 ✓

1

(f)(ii) length a

diagonal of cube face = 4r



$2a^2 = 16\ r^2$
$a^2 = 8r^2$
$a = 2\sqrt{2}\ r = 2.83\ r$ ✓

1

volume of cube

$= (2\sqrt{2})^3\ r^3 = 16\sqrt{2}\ r^3 = 22.63\ r^3$ ✓

1

(f)(iii) atomic radius of Ca

1.55 g Ca ≡ 1 cm^3 of bulk structure = $10^{-6}\ m^3$

$\frac{1.55}{40.08} \times 6.022 \times 10^{23}$ atoms ≡ $10^{-6}\ m^3$

also know 4 atoms in the bulk structure take up $16\sqrt{2}\ r^3\ m^3$

so 4 atoms in $\frac{4 \times 40.08 \times 10^{-6}}{1.55 \times 6.022 \times 10^{23}}\ m^3 \equiv 16\sqrt{2}\ r^3\ m^3$

$r^3 = \frac{4 \times 40.08 \times 10^{-6}}{16\sqrt{2} \times 1.55 \times 6.022 \times 10^{23}}\ m^3 \equiv$

$r = \sqrt[3]{\frac{4 \times 40.08 \times 10^{-6}}{16\sqrt{2} \times 1.55 \times 6.022 \times 10^{23}}}\ m = 1.97 \times 10^{-10}\ m$ ✓✓✓

or 197 pm

3

[up to one mark partial credit if a decent attempt]

Page total 6

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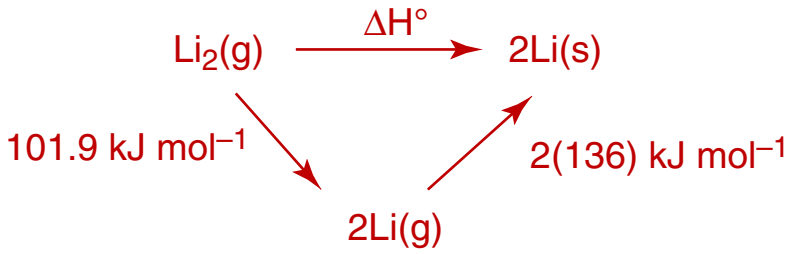
1(g) standard enthalpy change:



$\Delta H° = 101.9 - 2(136) = -170.1$ kJ mol^{-1} ✓ 1

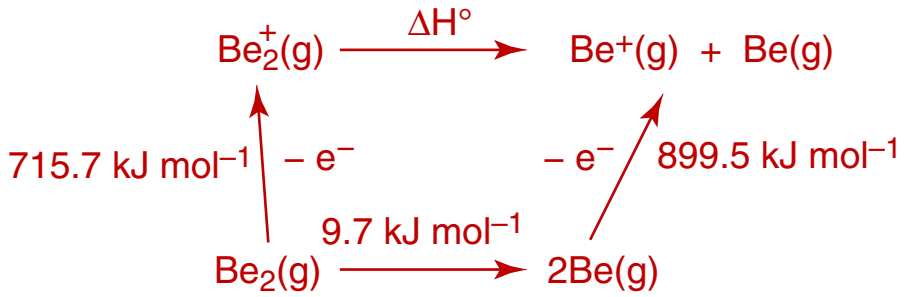
[1 mark if correct number and sign]

(h)

	increases	decreases	remains constant
bond dissociation enthalpy		✓	
bond length	✓		

2

(i)(i) bond dissociation enthalpy



2

$\Delta H° = -715.7 + 9.7 + 899.5 = \underline{\underline{193.5 \text{ kJ mol}^{-1}}}$ ✓✓

[1 mark if correct number but wrong sign]

(i)(ii)

	increases	decreases	remains constant
bond length		✓	

1

Page total 6

leave blank

2(a)(i) molecular formulae

I	II
$C_6H_5Cl_2N$ ✓	$C_7H_5ClO_2$ ✓

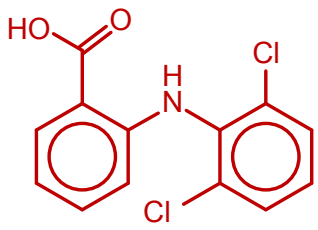
2

(a)(ii) equation:

$$C_6H_5Cl_2N + KOH + C_7H_5ClO_2 \longrightarrow KCl + H_2O + C_{13}H_9Cl_2NO_2$$ ✓

1

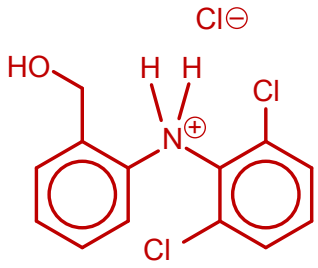
(a)(iii) structure of Compound A:



✓

1

(b) structure of hydrochloride salt



✓

1

(c)(i)

Nucleophile ✓ **Electrophile** **Radical** **Catalyst**

1

(c)(ii)

Hydrolysis **Condensation** **Oxidation** **Reduction** ✓ **Isomerisation**

1

Page total 7

leave blank

2(d)(i)

Compound B[1]

5 ✓✓

[1 mark for **4**]

(d)(ii)

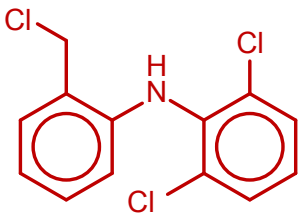
Compound B[2]

3 ✓

3

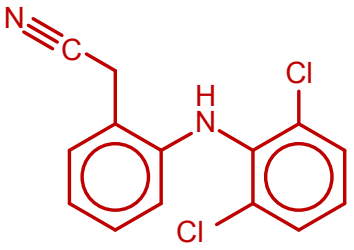
(e)(i) **Nucleophile** ✓ **Electrophile** **Radical** **Catalyst** 1

(e)(ii) **structure of Compound C:**

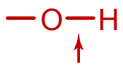


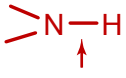
✓ 1

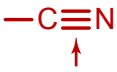
structure of Compound D:

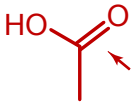


✓ 1

(f)(i)  ✓1/2

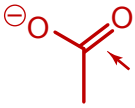
(f)(ii)  ✓1/2

(f)(iii)  ✓1/2

(f)(iv)  ✓1/2

[C=O in carboxylic acid]

3

(f)(v)  ✓

[C=O in carboxylate ion]

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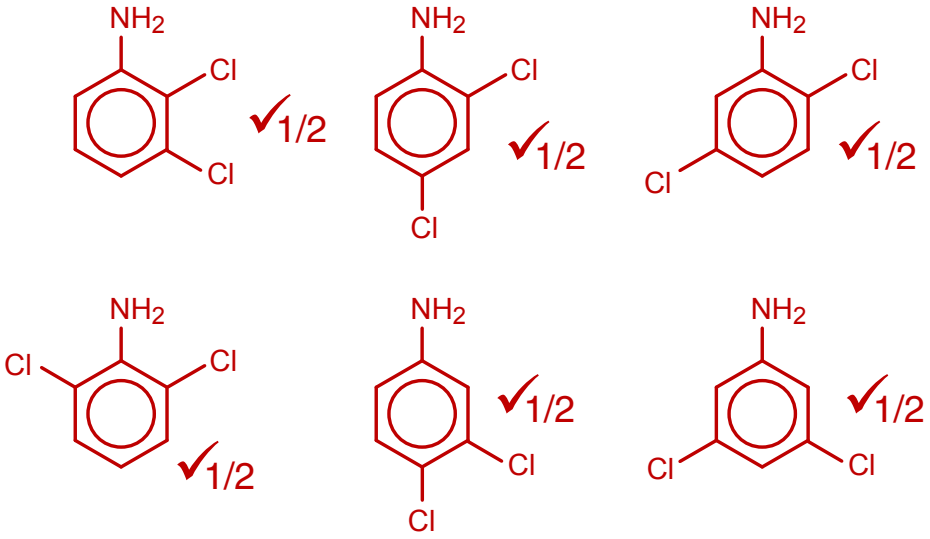
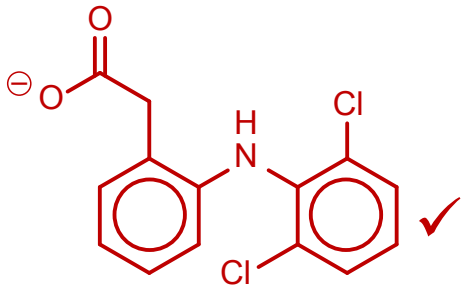
2(g) isomers



3

[subtract 1/2 for each duplicate or wrong answer but no overall negative mark]

(h) anion:



1

(i) percentage peak height:

$(0.989)^{14} \times (0.758)^2 = 0.492 = 49.2\%$ ✓✓

2

(j)(i) formulae:

$(^{12}C)_{13}(^{13}C)(^{1}H)_{10}(^{35}Cl)_2(^{14}N)(^{16}O)_2^{\ominus}$ ✓

1

(j)(ii) percentage peak height:

$14 \times (0.989)^{13} \times (0.011) \times (0.758)^2 = 0.077 = 7.7\%$ ✓✓

2

[1 mark if forgot factor of 14, i.e. 0.0055 = 0.55%]

Page total 9

leave blank

2(k)(i) molecular formulae:

uric acid	allantoin
$C_5H_4N_4O_3$ ✓	$C_4H_6N_4O_3$ ✓

2

(k)(ii)

X	Y
H_2O_2 ✓	CO_2 ✓

2

(k)(iii) equation:

$$C_5H_4N_4O_3 + O_2 + 2H_2O \longrightarrow C_4H_6N_4O_3 + H_2O_2 + CO_2$$ ✓

1

(l) amount of uric acid:

$1000\ cm^3 \equiv 230\ \mu mol \equiv 230 \times 10^{-6}\ mol$

$\therefore 20\ cm^3 \equiv 1.0\ g$ tissue

$$\equiv \frac{230 \times 10^{-6}}{1000} \times 20 = 4.6 \times 10^{-6}\ mol\ g^{-1}\ tissue$$

$= 4.6 \times 10^{-3}\ mol\ kg^{-1}$ tissue

RMM of uric acid

$= (5 \times 12.01) + (4 \times 1.008) + (4 \times 14.01) + (3 \times 16.00)$

$= 168.122\ g\ mol^{-1}$

2

so concentration =

$= (4.60 \times 10^{-3} \times 168.122) = 0.77\ g\ kg^{-1} = 770\ mg\ kg^{-1}$ ✓✓

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