

# Interactive Example Candidate Responses

## Paper 42 (May/June 2016), Question 1

### Cambridge International AS & A Level Chemistry 9701

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Answer all questions in the spaces provided.

- 1 (a) Magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2$ , is very soluble in water. When a hot saturated solution of magnesium nitrate is cooled, crystals of the hydrate,  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , are formed. In the crystals, six water molecules bond to each  $\text{Mg}^{2+}$  ion, and some of these water molecules are also bonded to the nitrate ions.

- (i) Suggest the type of bonding that occurs between

$\text{H}_2\text{O}$  and  $\text{Mg}^{2+}$ , ..... covalent bond

$\text{H}_2\text{O}$  and  $\text{NO}_3^-$ , ..... ionic bond.

[2]

- (ii) Describe the arrangement of the water molecules around the  $\text{Mg}^{2+}$  ion.

The arrangement is such that the shape is octahedral. [1]

- (iii) Describe in detail what you would observe when crystals of  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  are heated in a boiling tube, gently at first and then more strongly. Write equations for any reactions that occur.

Initially, water vapour is produced.

$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} \rightarrow \text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}$

After more stronger heating, brown fumes are produced ( $\text{NO}_2$ ) and a white solid is left ( $\text{MgO}$ ).

$\text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$

[4]

- (iv) Calculate the percentage loss in mass when  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  is heated strongly to constant mass.

Molar mass of  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = 24.3 + 2[14 + 3(16)] + 6[2 + 16]$   
 $= 256.3$

Molar mass of  $\text{MgO} = 24.3 + 16 = 40.3$

$\therefore \text{Percentage loss} = \frac{256.3 - 40.3}{256.3} \times 100\%$

$= 84.3\%$

percentage loss = 84.3 % [2]

Your  
Mark

1(a)(i)

1(a)(ii)

1(a)(iii)

1(a)(iv)

1(b)

1(c)

Q1	Mark scheme
(a)(i)	dative (covalent) or coordinate Hydrogen / H (bonding) [2]
(a)(ii)	octahedral [1]
(a)(iii)	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} \rightarrow \text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}$ $\text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$ any three of (solid) dissolves / turns to liquid condensation on tube white solid (forms / remains) brown fumes (evolved) gas formed that relights a glowing splint [4]
(a)(iv)	$M_r$ values: $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = 256.3$ $\text{MgO} = 40.3$ or (loss in molar mass = $256.3 - 40.3 = 216$ ) percentage loss = $100 \times 216 / 256.3 = 84.3 / 84.4\%$ [2]
(b)	(cat)-ionic radius / ion size increases (down the group) less polarisation / distortion of nitrate ion / $\text{NO}_3^-$ [2]
(c)	$2\text{AgNO}_3 \rightarrow 2\text{Ag} + 2\text{NO}_2 + \text{O}_2$ [1]
[Total: 12]	

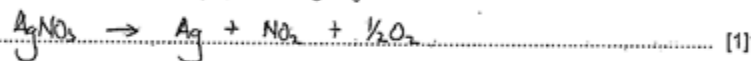
(b) Explain why the Group 2 nitrates become more stable to heat down the group.

Going down the group, size of cation increases.  
Polarising power of cation decreases down Group 2.  
Bonding between nitrate ion and Group 2 cation becomes more ionic  
and so thermal stability increases.

[2]

(c) Magnesium nitrate and silver nitrate,  $\text{AgNO}_3$ , decompose on heating to produce the same gases. Silver nitrate also produces silver metal during decomposition.

Write an equation for the decomposition of  $\text{AgNO}_3$ .



[1]

[Total: 12]

Your  
Mark

1(a)(i)

1(a)(ii)

1(a)(iii)

1(a)(iv)

1(b)

1(c)

Q1	Mark scheme
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(b)	cat-ionic radius / ion size increases (down the group) less polarisation / distortion of nitrate ion / $\text{NO}_3^-$ [2]
(c)	$2\text{AgNO}_3 \rightarrow 2\text{Ag} + 2\text{NO}_2 + \text{O}_2$ [1] [Total: 12]

Answer all questions in the spaces provided.

- 1 (a) Magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2$ , is very soluble in water. When a hot saturated solution of magnesium nitrate is cooled, crystals of the hydrate,  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , are formed. In the crystals, six water molecules bond to each  $\text{Mg}^{2+}$  ion, and some of these water molecules are also bonded to the nitrate ions.

- (i) Suggest the type of bonding that occurs between

$\text{H}_2\text{O}$  and  $\text{Mg}^{2+}$ , ~~ionic bonding~~ co-ordinate bonding

$\text{H}_2\text{O}$  and  $\text{NO}_3^-$ , covalent bonding

[2]

- (ii) Describe the arrangement of the water molecules around the  $\text{Mg}^{2+}$  ion.

a Hexagonal

[1]

- (iii) Describe in detail what you would observe when crystals of  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  are heated in a boiling tube, gently at first and then more strongly. Write equations for any reactions that occur.

At first, when  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  are heated, steam would be seen on the inside of the boiling tube as the crystals are dehydrated.

$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}(\text{g})$

when heated strongly, a brown gas is seen on the inside of the tube and being emitted, this is the nitrogen gas which has a strong smell.

$\text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$

~~$2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$~~

[4]

- (iv) Calculate the percentage loss in mass when  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  is heated strongly to constant mass.

$$n = \frac{m}{M_r}$$

$$M = 108 \text{ g of } \text{H}_2\text{O}$$

$$(\text{NO}_3)_2 = 124 \text{ g}$$

$$\text{Mg} = 24 \text{ g}$$

$$256$$

$$\begin{array}{r} 256 \\ - 108 \\ \hline 148 \\ - 92 \\ \hline 56 \end{array}$$

$$\begin{array}{r} 256 \\ - 40 \\ \hline 216 \end{array}$$

216 → lost

$$\therefore \frac{216}{256} \times 100 = 84.375\% \approx 84.4\%$$

percentage loss = 84.4 % [2]

Your  
Mark

1(a)(i)

1(a)(ii)

1(a)(iii)

1(a)(iv)

1(b)

1(c)

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[Total: 12]	

(b) Explain why the Group 2 nitrates become more stable to heat down the group.

*As the lattice energy increases down the group, Group 2 nitrates become more stable to heat and don't decompose easily.*

[2]

(c) Magnesium nitrate and silver nitrate,  $\text{AgNO}_3$ , decompose on heating to produce the same gases. Silver nitrate also produces silver metal during decomposition.

Write an equation for the decomposition of  $\text{AgNO}_3$ .

*$2\text{AgNO}_3 \xrightarrow{\Delta} 2\text{Ag} + 2\text{NO}_2 + \text{O}_2$*

[1]

[Total: 12]

Your  
Mark

1(a)(i)

1(a)(ii)

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1(a)(iv)

1(b)

1(c)

Q1	Mark scheme
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- (i) Suggest the type of bonding that occurs between

$\text{H}_2\text{O}$  and  $\text{Mg}^{2+}$ , ..... dative covalent bond.

$\text{H}_2\text{O}$  and  $\text{NO}_3^-$ , ..... hydrogen bond. [2]

- (ii) Describe the arrangement of the water molecules around the  $\text{Mg}^{2+}$  ion.

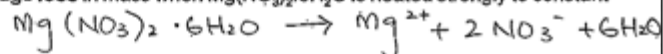
..... In octahedral shape. [1]

- (iii) Describe in detail what you would observe when crystals of  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  are heated in a boiling tube, gently at first and then more strongly. Write equations for any reactions that occur.

..... When  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  is heated a so the water will evaporate leaving  $\text{Mg}(\text{NO}_3)_2$  in crystal form. Heating strongly will give assurity that at the end  $\text{H}_2\text{O}$  is evaporated

.....  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} \rightarrow \text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}$ . [4]

- (iv) Calculate the percentage loss in mass when  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  is heated strongly to constant mass.



percentage loss = 2 % [2]

Your  
Mark

1(a)(i)

1(a)(ii)

1(a)(iii)

1(a)(iv)

1(b)

1(c)

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[Total: 12]	



(b) Explain why the Group 2 nitrates become more stable to heat down the group.

As we go down the group the ionic size increase. As the valence shell increases so there is less attraction. As a result polarisation decreases as lattice energy and hydration energy decrease. [2]

(c) Magnesium nitrate and silver nitrate,  $\text{AgNO}_3$ , decompose on heating to produce the same gases. Silver nitrate also produces silver metal during decomposition.

Write an equation for the decomposition of  $\text{AgNO}_3$ .



[Total: 12]

Your  
Mark

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Cambridge Assessment International Education  
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom  
t: +44 1223 553554 f: +44 1223 553558  
e: [info@cambridgeinternational.org](mailto:info@cambridgeinternational.org) [www.cambridgeinternational.org](http://www.cambridgeinternational.org)

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