

## Energy Changes of Salts

**Subject & topics:** Chemistry | Inorganic | Bonding & IMFs      **Stage & difficulty:** A Level P1

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### Part A

#### $\text{CaCl}_2$ or $\text{CaCl}$ ?

Which statement helps to explain why calcium and chlorine form  $\text{CaCl}_2$  rather than  $\text{CaCl}$  ?

- ☐ Less energy is required to remove one electron from the calcium atom than to remove two electrons.
- ☐ The lattice energy of  $\text{CaCl}(\text{s})$  is less exothermic than that of  $\text{CaCl}_2(\text{s})$ .
- ☐ When  $\text{CaCl}(\text{s})$  is formed from its elements, more energy is released than when  $\text{CaCl}_2(\text{s})$  is formed from its elements.
- ☐ More energy is released in forming chloride ions from chlorine molecules in the formation of  $\text{CaCl}_2(\text{s})$  than in the formation of  $\text{CaCl}(\text{s})$ .

**Part B**

**Enthalpy of solution of magnesium chloride**

The lattice enthalpy of magnesium chloride is  $+2493 \text{ kJ mol}^{-1}$ . The hydration enthalpy of the magnesium ion is  $-1920 \text{ kJ mol}^{-1}$  and that of the chloride ion is  $-364 \text{ kJ mol}^{-1}$ .

The enthalpy of solution (in  $\text{kJ mol}^{-1}$ ) of magnesium chloride in water is given by:

- ☐  $-2493 - 1920 - 364$
- ☐  $+2493 - 1920 - (2 \times 364)$
- ☐  $-2493 + 1920 + (2 \times 364)$
- ☐  $+2493 - 1920 - 364$
- ☐  $+2493 + 1920 - (2 \times 364)$

Part A adapted with permission from UCLES, A-Level Chemistry, June 1996, Paper 3, Question 7;

Part B adapted with permission from OCSEB, A-Level Chemistry, June 1995, Paper 1, Question 9

## Intermolecular Forces

**Subject & topics:** Chemistry | Inorganic | Bonding & IMFs    **Stage & difficulty:** A Level P2

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### Part A

#### Liquid hydrogen halides

Which quantity would best indicate the relative strengths of the hydrogen bond between the molecules in liquid hydrogen halides?

- ☐ bond dissociation energies
- ☐ enthalpy changes of solution
- ☐ enthalpy changes of formation
- ☐ enthalpy changes of vaporisation

### Part B

#### Propanone and hexane

Propanone is much more soluble than hexane in water.

Which statement helps to account for this?

- ☐ A hydrogen bond forms between the oxygen of the  $\text{C}=\text{O}$  group in propanone and the hydrogen of a water molecule
- ☐ A hydrogen bond forms between the oxygen of the  $\text{C}=\text{O}$  group in propanone and the oxygen of a water molecule
- ☐ A hydrogen bond forms between the hydrogen of the  $\text{CH}_3$  group in propanone and the hydrogen of a water molecule
- ☐ A hydrogen bond forms between the hydrogen of the  $\text{CH}_3$  group in propanone and the oxygen of a water molecule

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## Ionisation Energy and Radii

**Subject & topics:** Chemistry | Inorganic | Periodic Table

**Stage & difficulty:** A Level P1

### Part A

#### Ionisation energy

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic	→	most endothermic
<b>A</b>	Fr	Ra	Rn
<b>B</b>	Fr	Rn	Ra
<b>C</b>	Ra	Fr	Rn
<b>D</b>	Rn	Ra	Fr

- ☐ **A**  
☐ **B**  
☐ **C**  
☐ **D**

**Part B**  
**Radii**

The following species contain the same number of electrons.

In which order do their radii increase?

	smallest radius	→	largest radius
<b>A</b>	Ar	$K^+$	$Ca^{2+}$
<b>B</b>	$Ca^{2+}$	Ar	$K^+$
<b>C</b>	$Ca^{2+}$	$K^+$	Ar
<b>D</b>	$K^+$	$Ca^{2+}$	Ar

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

Part A adapted with permission from UCLES, A-Level Chemistry, November 1999, Paper 3, Question 4;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1999, Paper 3, Question 13

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## More Periodic Trends

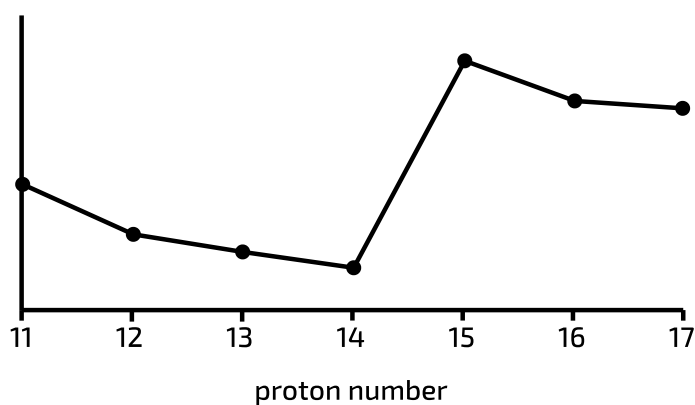
**Subject & topics:** Chemistry | Inorganic | Periodic Table    **Stage & difficulty:** A Level P1

The graphs below show how a property of the elements Na to Cl varies with proton number.

What is the property of each trend?

### Part A

#### Trend 1



**Figure 1:** Trend 1 of the elements Na to Cl with proton number

What is the property?

- ☐ melting point
- ☐ electronegativity
- ☐ first ionisation energy
- ☐ ionic radius

Part B

Trend 2

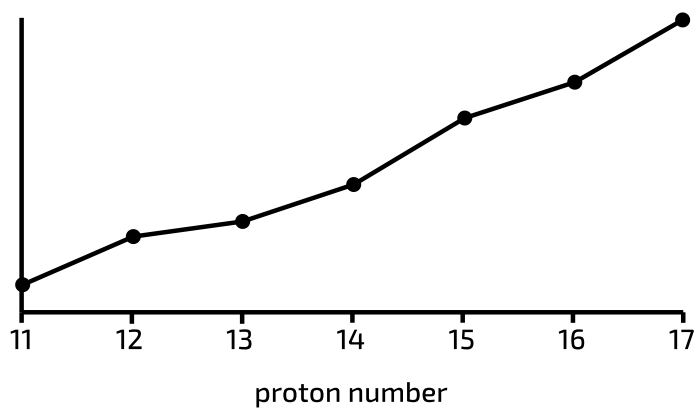


Figure 2: Trend 2 of the elements Na to Cl with proton number

What is the property?

- ☐ melting point
- ☐ first ionisation energy
- ☐ ionic radius
- ☐ electronegativity



Part C  
Trend 3

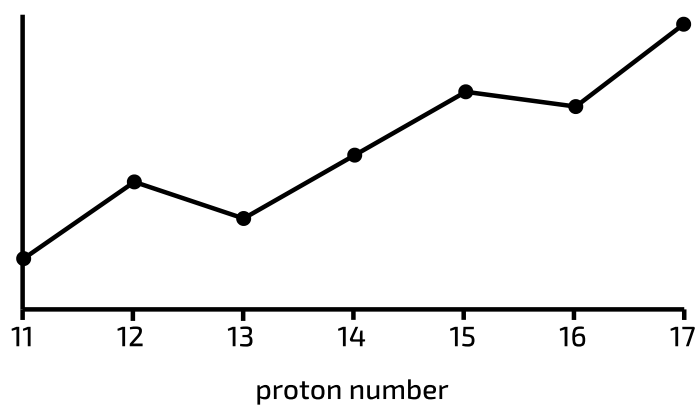


Figure 3: Trend 3 of the elements Na to Cl with proton number

What is the property?

- ☐ ionic radius
- ☐ melting point
- ☐ first ionisation energy
- ☐ electronegativity

Part A adapted with permission from UCLES, A-Level Chemistry, June 1996, Paper 3, Question 12;  
Parts B, C created for Isaac Physics by R. Less

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## Groups 1 and 2

**Subject & topics:** Chemistry | Inorganic | Periodic Table      **Stage & difficulty:** A Level P1

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### Part A

#### Lithium compounds

Lithium resembles magnesium in its chemical properties.

Which property of lithium compounds is unlikely to be correct?

- ☐ Lithium carbonate decomposes to give carbon dioxide on being heated.
- ☐ Lithium oxide in water produces a solution with pH greater than 7.
- ☐ Lithium sulfate is soluble in water.
- ☐ Lithium nitrate gives oxygen as the only gas on being heated.

### Part B

#### Group 2 trends

On descending Group 2 from magnesium to barium, which statement correctly describes the trend in properties?

- ☐ The ionic radius decreases.
- ☐ The enthalpy change of hydration of the  $+2$  ion becomes less negative.
- ☐ The first ionisation energy increases.
- ☐ The solubility of the sulfate increases.

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## Group 2 Salts

**Subject & topics:** Chemistry | Inorganic | Periodic Table

**Stage & difficulty:** A Level P1

### Part A

#### Silver nitrate and barium chloride

An **excess** of aqueous silver nitrate is added to aqueous barium chloride, and the precipitate is removed by filtration.

What are the main ions in the filtrate?

- ☐  $\text{Ag}^+$ ,  $\text{Ba}^{2+}$  and  $\text{NO}_3^-$
- ☐  $\text{Ag}^+$  and  $\text{NO}_3^-$  only
- ☐  $\text{Ba}^{2+}$ ,  $\text{NO}_3^-$  and  $\text{Cl}^-$
- ☐  $\text{Ba}^{2+}$  and  $\text{NO}_3^-$  only

**Part B**

**Salts with dilute hydrochloric acid**

When a mixture of white solids, **X**, is treated with an excess of dilute hydrochloric acid, a colourless gas is evolved and some, but not all, of the mixture dissolves.

Which mixture could be **X**?

- ☐  $\text{BaSO}_4$  and  $\text{CaCO}_3$
- ☐  $\text{Ba}(\text{NO}_3)_2$  and  $\text{Ca}(\text{OH})_2$
- ☐  $\text{CaCO}_3$  and  $\text{MgSO}_4$
- ☐  $\text{Ca}(\text{OH})_2$  and  $\text{MgCO}_3$

Part A adapted with permission from OCR, A-Level Chemistry, June 1999, Paper 3, Question 17;

Part B adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 4, Question 12

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## Halogen Trends

**Subject & topics:** Chemistry | Inorganic | Periodic Table

**Stage & difficulty:** A Level P1

### Part A

#### Periodic trends

Which statements about the trends in the properties of the halogens are correct?

1. The electronegativity decreases on descending the group.
2. The volatility decreases on descending the group.
3. Their reactivity as oxidising agents decreases on descending the group.

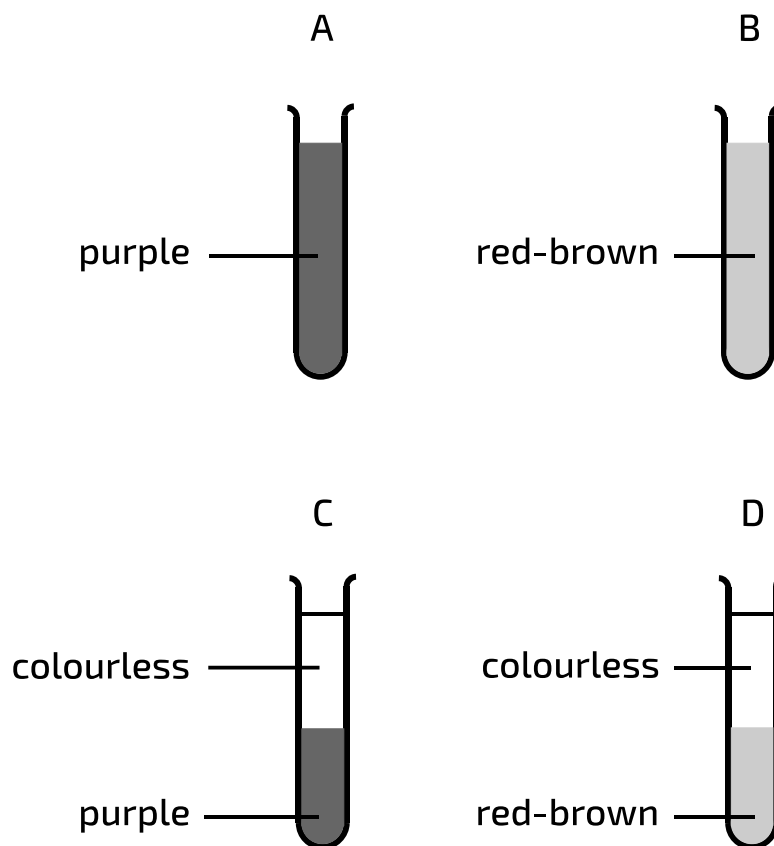
- ☐ 1, 2 and 3 are correct
- ☐ 1 and 2 only are correct
- ☐ 2 and 3 only are correct
- ☐ 1 only is correct
- ☐ 3 only is correct

Part B

Oxidation and reduction

Aqueous chlorine is added to aqueous sodium bromide and the mixture is shaken with an equal volume of trichloroethane.

Which observation would be made?



**Figure 1:** Possible observations of aqueous chlorine with aqueous sodium bromide and an equal volume of trichloroethane

- ☐ A
- ☐ B
- ☐ C
- ☐ D

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## Halides Oxidation and Reduction

**Subject & topics:** Chemistry | Inorganic | Periodic Table

**Stage & difficulty:** A Level P1

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### Part A

#### Reactions of chlorine

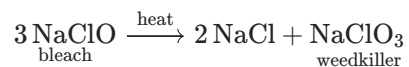
Which compound reacts with chlorine to give two products in which chlorine has different oxidation numbers?

- ☐ potassium iodide
- ☐ potassium iodate(V)
- ☐ ethene
- ☐ sodium hydroxide

**Part B**

**Weedkiller from bleach**

A weedkiller can be prepared by heating a bleach solution.



What are the oxidation numbers of chlorine in these three compounds?

	NaClO	NaCl	NaClO <sub>3</sub>
<b>A</b>	−1	−1	+5
<b>B</b>	+1	−1	+5
<b>C</b>	+1	−1	+7
<b>D</b>	+2	+1	+7

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

Part A adapted with permission from UCLES, A-Level Chemistry, June 1996, Paper 3, Question 15;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1999, Paper 3, Question 17

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## Oxidation Numbers

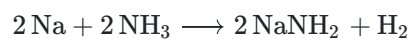
**Subject & topics:** Chemistry | Inorganic | Redox      **Stage & difficulty:** A Level P1

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### Part A

#### Sodium with ammonia

Sodium reacts with ammonia to give hydrogen and sodamide which is ionic.



Which changes in oxidation number of the three elements involved occur?

1.  $-3$  to  $-2$
2.  $0$  to  $+1$
3.  $+1$  to  $0$

- ☐ 1, 2 and 3 are correct
- ☐ 1 and 2 only are correct
- ☐ 2 and 3 only are correct
- ☐ 1 only is correct
- ☐ 3 only is correct

**Part B****Titanium**

Titanium is manufactured from ilmenite which is a mixture of iron(II) titanate,  $\text{FeTiO}_3$ , and iron(III) titanate,  $\text{Fe}_2(\text{TiO}_3)_3$ .

What is the oxidation number of titanium in each of these compounds?

	$\text{FeTiO}_3$	$\text{Fe}_2(\text{TiO}_3)_3$
<b>A</b>	+2	+3
<b>B</b>	+4	+2
<b>C</b>	+4	+3
<b>D</b>	+4	+4

- ☐ A
- ☐ B
- ☐ C
- ☐ D

Part A adapted with permission from UCLES, A-Level Chemistry, June 1999, Paper 3, Question 33;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1997, Paper 3, Question 13

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## Hydroxylamine and Iron(III)

**Subject & topics:** Chemistry | Inorganic | Redox      **Stage & difficulty:** A Level C1

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The following experiment was used to determine the equation for the reaction between hydroxylamine,  $\text{NH}_2\text{OH}$ , and iron(III) ions. 0.0370 g of hydroxylamine was dissolved in water and made up to  $25.0\text{ cm}^3$ . This solution was reacted with an excess of an acidified solution of an iron(III) salt. When the reaction was complete the iron(II) produced required  $22.4\text{ cm}^3$  of  $0.0200\text{ mol dm}^{-3}$  potassium manganate(VII) solution to oxidise the iron(II) back to iron(III).

### Part A

#### Hydroxylamine oxidation number

What is the oxidation number of nitrogen in hydroxylamine,  $\text{NH}_2\text{OH}$ ?

### Part B

#### Oxidation of iron(II)

Write down the half-equation for the oxidation of iron(II) to iron(III) ions.

### Part C

#### Reduction of manganate(VII)

Write down the half-equation for the reduction of manganate(VII) to manganese(II) ions under acidic conditions.

**Part D**

**Ionic equation**

Deduce the ionic equation for the reaction between iron(II) ions and manganate(VII) ions under acidic conditions.

**Part E**

**Moles of hydroxylamine**

Calculate the amount, in moles, of hydroxylamine used in the reaction.

**Part F**

**Moles of iron(II)**

Calculate the amount, in moles, of iron(II) formed in the reaction.

**Part G**

**Molar ratio of iron(III) to hydroxylamine**

Determine the molar ratio of iron(III) to hydroxylamine reacting together.

**Part H**

**Oxidation number of nitrogen in the product**

Using the oxidation number of nitrogen in hydroxylamine, and the molar ratio of iron(III) to hydroxylamine, deduce the oxidation number of nitrogen in the product.

**Part I**

**Nitrogen-containing product**

Which of the following possible nitrogen-containing compounds is the most likely product of the reaction?

- ☐  $\text{N}_2\text{O}$
- ☐  $\text{NO}$
- ☐  $\text{N}_2$
- ☐  $\text{N}_2\text{O}_4$
- ☐  $\text{NH}_3$

**Part J**

**Hydroxylamine and iron(III) equation**

Write the equation for the reaction between hydroxylamine and iron(III) ions. State symbols are not required.