# Atomic Structure

## Question Paper 5

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|---|---|
| **Level** | International A Level |
| **Subject** | Chemistry |
| **Exam Board** | CIE |
| **Topic** | Atomic Structure |
| **Sub-Topic** | |
| **Paper Type** | Theory |
| **Booklet** | Question Paper 5 |

**Time Allowed:** **86 minutes**

**Score:** **/71**

**Percentage:** **/100**

**Grade Boundaries:**

| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | 777.5% | 70% | 62.5% | 57.5% | 45% | <45% |

**1** The elements of Group VII of the Periodic Table show variation in their properties.

**(a) (i)** Complete the table below, stating the colour of each element in its normal state at room temperature.

| halogen | melting point / °C | colour |
|---|---|---|
| chlorine | –101 | |
| bromine | –7 | |
| iodine | 114 | |

**(ii)** Briefly explain why the melting points of the halogens increase from chlorine to iodine.

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.....

.....

[4]

**(b)** The halogens form many interhalogen compounds in which two different halogens are combined. One such compound is bromine monochloride, BrCl.

**(i)** Complete the electronic configurations of chlorine and bromine.

| | |
|---|---|
| chlorine | $1s^2 2s^2 2p^6$ |
| bromine | $1s^2 2s^2 2p^6$ |

**(ii)** Draw a 'dot-and-cross' diagram of the BrCl molecule.
Show outermost electrons only.

[2]

**(c)** Interhalogen compounds like BrCl have similar properties to the halogens.

**(i)** By considering your answers to **(a)** and **(b)**, predict the physical state of BrCl at room temperature. Explain your answer.

physical state .....

explanation .....

.....

.....

**(ii)** Suggest the colour of BrCl.

.....

[4]

**(d)** $Cl_2$ and BrCl each react with aqueous KI.

**(i)** Describe what would be seen when $Cl_2$ is bubbled through aqueous KI for several minutes.

initially .....

.....

after several minutes .....

.....

**(ii)** Construct an equation for the reaction that occurs.

.....

**(iii)** Suggest an equation for the reaction that occurs between BrCl and aqueous KI.

.....

**(iv)** How do $Cl_2$ and BrCl behave in these reactions?

.....

[5]

[Total: 15]

**2** The technique of DNA fingerprinting has been one of the most important developments in biochemical analysis in recent times. It has enabled enormous advances to be made in forensic science, medicine and archaeology.

**(a)** The table shows different stages in the production of a genetic fingerprint. Use the numbers 1 to 6 to put the stages in the correct sequence in the blank column.

| stages | process | correct sequence (numbers) |
|---|---|---|
| A | place samples on agarose gel | |
| B | use polymerase chain reaction | |
| C | label with radioactive isotope | |
| D | extract DNA | |
| E | use restriction enzyme | |
| F | carry out electrophoresis | |

[3]

**(b)** One of the stages above uses a radioactive isotope.

**(i)** What isotope is used? .....

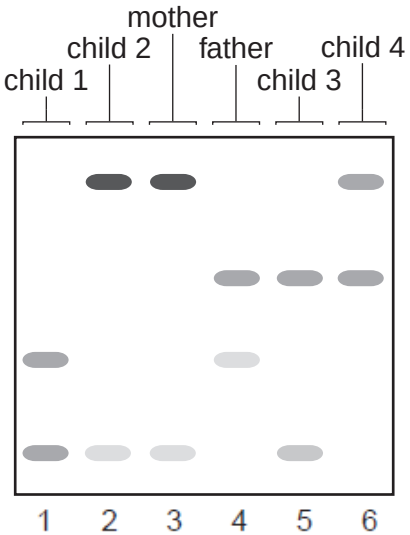
**(ii)** Why is this isotope chosen?

.....

.....

[2]

**(c)** The following DNA fingerprints were taken from a family of mother, father and four children.



**(i)** Are all of the children related to the mother? State the evidence for your answer.

.....

.....

**(ii)** Which child is unlikely to be related to the father? State the evidence for your answer.

.....

.....

[2]

**(d)** DNA fingerprinting has been successfully used in archaeological investigations.

**(i)** Ancient writings were often made on goatskins. Over the centuries these have often become broken into fragments, making reconstruction of the writings almost impossible.

Suggest how the use of DNA fingerprinting might be able to identify which fragments came from a particular skin.

.....

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**(ii)** Apart from the examples of human remains and goatskins, state one other material that could be investigated using this technique.

.....

.....

[3]

[Total: 10]

**3** **(a)** Explain what is meant by the term *transition element*.

.....

..... [1]

**(b)** Complete the electronic configuration of

**(i)** the vanadium atom, $1s^2 2s^2 2p^6$ .....

**(ii)** the $Cu^{2+}$ ion. $1s^2 2s^2 2p^6$ .....

[2]

**(c)** List the **four** most likely oxidation states of vanadium.

..... [1]

**(d)** Describe what you would see, and explain what happens, when dilute aqueous ammonia is added to a solution containing $Cu^{2+}$ ions, until the ammonia is in an excess.

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..... [5]

**(e)** Copper powder dissolves in an acidified solution of sodium vanadate(V), $NaVO_3$, to produce a blue solution containing $VO^{2+}$ and $Cu^{2+}$ ions.
By using suitable half-equations from the *Data Booklet*, construct a balanced equation for this reaction.

..... [2]

[Total: 11]

**4** Magnesium, Mg, and radium, Ra, are elements in Group II of the Periodic Table.

Magnesium has three isotopes.

**(a)** Explain the meaning of the term *isotope.*

.....

.....

..... [2]

A sample of magnesium has the following isotopic composition by mass.

| isotope mass | 24 | 25 | 26 |
|---|---|---|---|
| % by mass | 78.60 | 10.11 | 11.29 |

**(b)** Calculate the relative atomic mass, $A_r$, of magnesium to **four** significant figures.

$A_r$ = .....
[2]

Radium, proton number 88, and uranium, proton number 92, are radioactive elements.

The isotope $^{226}Ra$ is produced by the radioactive decay of the uranium isotope $^{238}U$.

**(c)** Complete the table below to show the atomic structures of the isotopes $^{226}Ra$ and $^{238}U$.

| | number of | | |
|---|---|---|---|
| isotopes | protons | neutrons | electrons |
| $^{226}Ra$ | | | |
| $^{238}U$ | | | |

[3]

**(d)** Radium, like other Group II elements, forms a number of ionic compounds.

**(i)** What is the formula of the radium cation?

……

**(ii)** Use the *Data Booklet* to suggest a value for the energy required to form one mole of the gaseous radium cation you have given in **(i)** from one mole of gaseous radium atoms. Explain your answer.

.....

.....

..... [3]

[Total: 10]

**5** This question is about the elements in Group II of the Periodic Table, magnesium to barium.

**(a)** Complete the table below to show the electronic configuration of calcium atoms and of strontium ions, $Sr^{2+}$.

| | 1s | 2s | 2p | 3s | 3p | 3d | 4s | 4p | 4d |
|---|---|---|---|---|---|---|---|---|---|
| Ca | 2 | 2 | 6 | | | | | | |
| $Sr^{2+}$ | 2 | 2 | 6 | | | | | | |

[2]

**(b)** Explain the following observations.

**(i)** The atomic radii of Group II elements increase down the Group.

.....

.....

**(ii)** The strontium ion is smaller than the strontium atom.

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.....

**(iii)** The first ionisation energies of the elements of Group II decrease with increasing proton number.

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.....

[4]

**(c)** Samples of magnesium and calcium are placed separately in cold water and left for some time. In **each case**, describe what you would see and write a balanced equation for each reaction.

**(i)** magnesium

observation .....

.....

equation .....

**(ii)** calcium

observation .....

.....

equation .....

[6]

**(d)** Strontium nitrate, $Sr(NO_3)_2$ undergoes thermal decomposition.

**(i)** State one observation you would make during this reaction.

.....

.....

**(ii)** Write a balanced equation for this reaction.

.....

[4]

[Total: 16]

**6** Compounds of phosphorus have many uses in everyday life, e.g. fertilisers, matches and in water softeners.

**(a)** State the full electronic configuration of phosphorus.

.....[1]

**(b)** Phosphoric acid, $H_3PO_4$, is used in the manufacture of phosphate fertilisers.

Deduce the oxidation number of phosphorus in $H_3PO_4$.

.....[1]

**(c)** The salt sodium phosphate, $Na_3PO_4$, is a water-softening agent.

**(i)** Write the equation for the complete neutralisation of phosphoric acid with aqueous sodium hydroxide.

.....

Sodium phosphate was prepared from 50.0 $cm^3$ of 0.500 mol $dm^{-3}$ $H_3PO_4$ and an excess of aqueous sodium hydroxide.

**(ii)** How many moles of $H_3PO_4$ were used?

**(iii)** Use your equation in **(c)(i)** to calculate how many moles of sodium hydroxide are required.

[3]

**(d)** Phosphorus sulphide, $P_4S_3$, is used in small amounts in the tip of a match. On striking a match, this compound burns.

**(i)** Construct an equation for this reaction.

.....

**(ii)** Both oxides formed in **(i)** dissolve in water to give acidic solutions. Construct an equation for the reaction of each oxide with water.

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.....[4]

[Total : 9]