

## Location Entry Codes

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As part of CIE's continual commitment to maintaining best practice in assessment, CIE uses different variants of some question papers for our most popular assessments with large and widespread candidature. The question papers are closely related and the relationships between them have been thoroughly established using our assessment expertise. All versions of the paper give assessment of equal standard.

The content assessed by the examination papers and the type of questions is unchanged.

This change means that for this component there are now two variant Question Papers, Mark Schemes and Principal Examiner's Reports where previously there was only one. For any individual country, it is intended that only one variant is used. This document contains both variants which will give all Centres access to even more past examination material than is usually the case.

The diagram shows the relationship between the Question Papers, Mark Schemes and Principal Examiners' Reports that are available.

Question Paper	Mark Scheme	Principal Examiner's Report
Introduction	Introduction	Introduction
First variant Question Paper	First variant Mark Scheme	First variant Principal Examiner's Report
Second variant Question Paper	Second variant Mark Scheme	Second variant Principal Examiner's Report

### Who can I contact for further information on these changes?

Please direct any questions about this to CIE's Customer Services team at:

[international@cie.org.uk](mailto:international@cie.org.uk)

The titles for the variant items should correspond with the table above, so that at the top of the first page of the relevant part of the document and on the header, it has the words:

- First variant Question Paper / Mark Scheme / Principal Examiner's Report

or

- Second variant Question Paper / Mark Scheme / Principal Examiner's Report

as appropriate.



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
International General Certificate of Secondary Education

CANDIDATE  
NAME

CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**CHEMISTRY**

**0620/31**

Paper 3 (Extended)

**October/November 2008**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES**

Answer **all** questions.

A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part questions.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
<b>Total</b>	

This document consists of **12** printed pages.



1 Complete the following table.

*For  
Examiner's  
Use*

gas	test for gas
ammonia	
	bleaches damp litmus paper
hydrogen	
	relights a glowing splint
	turns limewater milky

[Total: 5]

2 There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium nitride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.  
Use o to represent an electron from a nitrogen atom.

[3]

(b) (i) Describe metallic bonding.

.....  
..... [3]

(ii) Use the above ideas to explain why  
metals are good conductors of electricity,

..... [1]  
metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....  
.....  
..... [3]

(ii) Diamond has a similar structure and consequently similar properties.  
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....  
..... [2]

[Total: 14]

3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is  $Fe_2O_3 \cdot 2H_2O$ .  
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

..... [2]

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....  
..... [2]

(b) (i) Name a reagent that can reduce iron(III) oxide to iron.

..... [1]

(ii) Write a symbol equation for the reduction of iron(III) oxide,  $Fe_2O_3$ , to iron.

..... [2]

(c) (i) Calculate the mass of one mole of  $Fe_2O_3 \cdot 2H_2O$ .

..... [1]

(ii) Use your answer to (i) to calculate the percentage of iron in rust.

.....  
..... [2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....  
..... [1]

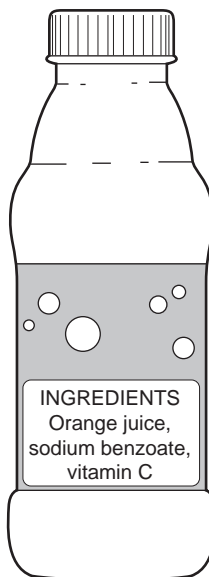
(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

.....  
..... [2]

[Total: 13]

- 4 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.

For  
Examiner's  
Use



- (a) Sodium benzoate is a salt, it has the formula  $C_6H_5COONa$ . It can be made by the neutralisation of benzoic acid by sodium hydroxide.

(i) Deduce the formula of benzoic acid.

..... [1]

(ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

..... [1]

(iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

- (b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

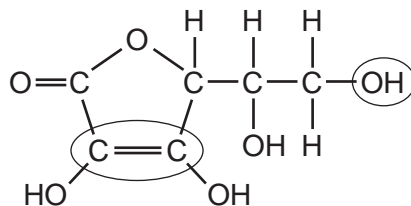
.....  
..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

(c) The structural formula of Vitamin C is drawn below.



For  
Examiner's  
Use

(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

[Total: 12]

5 The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals hydrogen, chlorine and sodium hydroxide.

For  
Examiner's  
Use

(a) The ions present are  $\text{Na}^+(\text{aq})$ ,  $\text{H}^+(\text{aq})$ ,  $\text{Cl}^-(\text{aq})$  and  $\text{OH}^-(\text{aq})$ .

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).



(ii) Complete the ionic equation for the reaction at the positive electrode (anode).



(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

..... [1]

(b) (i) Why does the water supply industry use chlorine?

..... [1]

(ii) Name an important chemical that is made from hydrogen.

..... [1]

(iii) How is sodium hydroxide used to make soap?

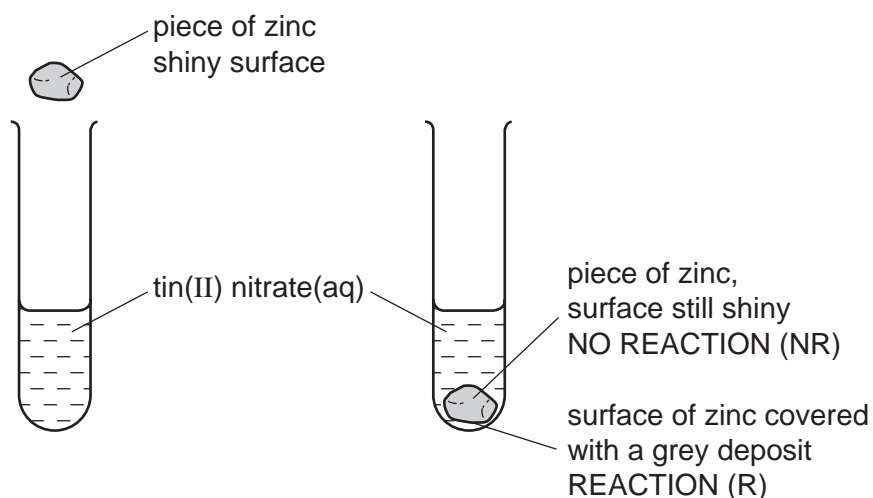
..... [2]

[Total: 7]



6 The reactivity series lists metals in order of reactivity.

- (a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out.



This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

- (i) The order was found to be:
- |           |                |
|-----------|----------------|
| manganese | most reactive  |
| zinc      |                |
| tin       |                |
| silver    | least reactive |

Complete the table of results from which this order was determined.

aqueous solution	tin Sn	manganese Mn	silver Ag	zinc Zn
tin(II) nitrate		R	NR	R
manganese(II) nitrate				
silver(I) nitrate				
zinc nitrate				

[3]

- (ii) Write the ionic equation for the reaction between tin atoms and silver(I) ions.

.....

[2]

For  
Examiner's  
Use

(iii) The following is a redox reaction.



Indicate on the equation the change which is oxidation.  
Give a reason for your choice.

..... [2]

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

.....  
..... [2]

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges,  $\text{K}^+$  and  $\text{Ca}^{2+}$ , their compounds behave differently when heated.

(i) Explain why the ions have different charges.

.....  
..... [2]

(ii) Their hydroxides are heated.  
If the compound decomposes, complete the word equation.  
If it does not decompose, write "no reaction".

Potassium hydroxide  $\longrightarrow$  .....

Calcium hydroxide  $\longrightarrow$  ..... [2]

(iii) Complete the equations for the decomposition of their nitrates.

$2\text{KNO}_3 \longrightarrow$  ..... + .....

$2\text{Ca}(\text{NO}_3)_2 \longrightarrow$  ..... + ..... + ..... [4]

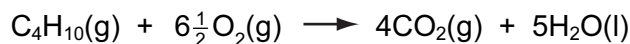
[Total: 17]

- 7 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

For  
Examiner's  
Use

(a) The complete combustion of an alkane gives carbon dioxide and water.

- (i) 10 cm<sup>3</sup> of butane is mixed with 100 cm<sup>3</sup> of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?



Volume of oxygen left = ..... cm<sup>3</sup>

Volume of carbon dioxide formed = ..... cm<sup>3</sup> [2]

- (ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....  
..... [2]

(b) The equation for a substitution reaction of butane is given below.



- (i) Name the organic product.

..... [1]

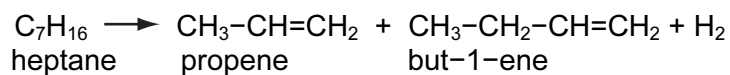
- (ii) This reaction does not need increased temperature or pressure. What is the essential reaction condition?

..... [1]

- (iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

- (c) Alkenes are more reactive and industrially more useful than alkanes.  
They are made by cracking alkanes.



- (i) Draw the structural formula of the polymer poly(propene).

[2]

- (ii) Give the structural formula and name of the alcohol formed when but-1-ene reacts with steam.

name .....

[1]

structural formula

[1]

- (iii) Deduce the structural formula of the product formed when propene reacts with hydrogen chloride.

[1]

[Total: 12]

For  
Examiner's  
Use

**DATA SHEET**  
**The Periodic Table of the Elements**

		Group																																																																																																																	
I	II	III	IV	V	VI	VII	0																																																																																																												
1 <b>H</b> Hydrogen																																																																																																																			
3 <b>Li</b> Lithium	4 <b>Be</b> Beryllium	5 <b>B</b> Boron	6 <b>C</b> Carbon	7 <b>N</b> Nitrogen	8 <b>O</b> Oxygen	9 <b>F</b> Fluorine	10 <b>Ne</b> Neon	11 <b>B</b> Boron	12 <b>C</b> Carbon	13 <b>Al</b> Aluminium	14 <b>Si</b> Silicon	15 <b>P</b> Phosphorus	16 <b>S</b> Sulphur	17 <b>Cl</b> Chlorine	18 <b>Ar</b> Argon	19 <b>K</b> Potassium	20 <b>Ca</b> Calcium	21 <b>Sc</b> Scandium	22 <b>Ti</b> Titanium	23 <b>V</b> Vanadium	24 <b>Cr</b> Chromium	25 <b>Mn</b> Manganese	26 <b>Fe</b> Iron	27 <b>Co</b> Cobalt	28 <b>Ni</b> Nickel	29 <b>Cu</b> Copper	30 <b>Zn</b> Zinc	31 <b>Ga</b> Gallium	32 <b>Ge</b> Germanium	33 <b>As</b> Arsenic	34 <b>Se</b> Selenium	35 <b>Br</b> Bromine	36 <b>Kr</b> Krypton	37 <b>Rb</b> Rubidium	38 <b>Sr</b> Strontium	39 <b>Y</b> Yttrium	40 <b>Zr</b> Zirconium	41 <b>Nb</b> Niobium	42 <b>Mo</b> Molybdenum	43 <b>Tc</b> Technetium	44 <b>Ru</b> Ruthenium	45 <b>Rh</b> Rhodium	46 <b>Pd</b> Palladium	47 <b>Ag</b> Silver	48 <b>Cd</b> Cadmium	49 <b>In</b> Indium	50 <b>Sn</b> Tin	51 <b>Sb</b> Antimony	52 <b>Te</b> Tellurium	53 <b>I</b> Iodine	54 <b>Xe</b> Xenon	55 <b>Cs</b> Caesium	56 <b>Ba</b> Barium	57 <b>La</b> Lanthanum	58 <b>Ce</b> Cerium	59 <b>Pr</b> Praseodymium	60 <b>Nd</b> Neodymium	61 <b>Pm</b> Promethium	62 <b>Sm</b> Samarium	63 <b>Eu</b> Europium	64 <b>Gd</b> Gadolinium	65 <b>Tb</b> Terbium	66 <b>Dy</b> Dysprosium	67 <b>Ho</b> Holmium	68 <b>Er</b> Erbium	69 <b>Tm</b> Thulium	70 <b>Yb</b> Ytterbium	71 <b>Lu</b> Lutetium	72 <b>Fr</b> Francium	73 <b>Ra</b> Radium	74 <b>Ac</b> Actinium	75 <b>Re</b> Rhenium	76 <b>Os</b> Osmium	77 <b>Ir</b> Iridium	78 <b>Pt</b> Platinum	79 <b>Au</b> Gold	80 <b>Hg</b> Mercury	81 <b>Tl</b> Thallium	82 <b>Pb</b> Lead	83 <b>Bi</b> Bismuth	84 <b>Po</b> Polonium	85 <b>At</b> Astatine	86 <b>Rn</b> Radon	87 <b>Fr</b> Francium	88 <b>Ra</b> Radium	89 <b>Ac</b> Actinium	90 <b>Th</b> Thorium	91 <b>Pa</b> Protactinium	92 <b>U</b> Uranium	93 <b>Np</b> Neptunium	94 <b>Pu</b> Plutonium	95 <b>Am</b> Americium	96 <b>Cm</b> Curium	97 <b>Bk</b> Berkelium	98 <b>Cf</b> Californium	99 <b>Es</b> Einsteinium	100 <b>Fm</b> Fermium	101 <b>Md</b> Mendelevium	102 <b>No</b> Nobelium	103 <b>Lr</b> Lawrencium	104 <b>Rf</b> Rutherfordium	105 <b>Db</b> Dubnium	106 <b>Sg</b> Seaborgium	107 <b>Bh</b> Bohrium	108 <b>Hs</b> Hassium	109 <b>Mt</b> Meitnerium	110 <b>Ds</b> Darmstadtium	111 <b>Rg</b> Roentgenium	112 <b>Cn</b> Copernicium	113 <b>Nh</b> Nihonium	114 <b>Fl</b> Flerovium	115 <b>Mc</b> Moscovium	116 <b>Lv</b> Livermorium	117 <b>Ts</b> Tennessine	118 <b>Og</b> Oganesson

\*58-71 Lanthanoid series  
†90-103 Actinoid series

a	<b>X</b>	a = relative atomic mass
b	<b>X</b>	X = atomic symbol
		b = proton (atomic) number

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
International General Certificate of Secondary Education

CANDIDATE  
NAME

CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**CHEMISTRY**

**0620/32**

Paper 3 (Extended)

**October/November 2008**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES**

Answer **all** questions.

A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part questions.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
<b>Total</b>	

This document consists of **12** printed pages.



1 Complete the following table.

*For  
Examiner's  
Use*

gas	test for gas
	turns damp red litmus paper blue
	bleaches damp litmus paper
hydrogen	
oxygen	
carbon dioxide	

[Total: 5]

2 There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium sulphide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.  
Use o to represent an electron from a sulphur atom.

[3]

(b) (i) Describe metallic bonding.

.....  
..... [3]

(ii) Use the above ideas to explain why  
metals are good conductors of electricity,

..... [1]

metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....  
.....  
..... [3]

(ii) Diamond has a similar structure and consequently similar properties.  
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....  
..... [2]

[Total: 14]



3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is  $Fe_2O_3 \cdot 2H_2O$ .  
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

..... and ..... [2]

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....  
..... [2]

(b) (i) Name a reagent that can reduce iron(III) oxide to iron.

..... [1]

(ii) Write a symbol equation for the reduction of iron(III) oxide,  $Fe_2O_3$ , to iron.

..... [2]

(c) (i) Calculate the mass of one mole of  $Fe_2O_3 \cdot 2H_2O$ .

..... [1]

(ii) Use your answer to (i) to calculate the percentage of water in rust.

.....  
..... [2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....  
..... [1]

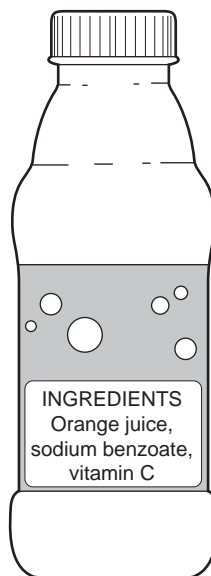
(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

.....  
..... [2]

[Total: 13]

- 4 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.

For  
Examiner's  
Use



- (a) Sodium benzoate is a salt, it has the formula  $C_6H_5COONa$ . It can be made by the neutralisation of benzoic acid by sodium hydroxide.

- (i) Deduce the formula of benzoic acid.

..... [1]

- (ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

..... [1]

- (iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

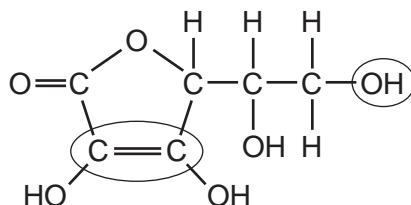
.....  
..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

(c) The structural formula of Vitamin C is drawn below.



(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

[Total: 12]

- 5 The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals; hydrogen, chlorine and sodium hydroxide.

For  
Examiner's  
Use

(a) The ions present are  $\text{Na}^+(\text{aq})$ ,  $\text{H}^+(\text{aq})$ ,  $\text{Cl}^-(\text{aq})$  and  $\text{OH}^-(\text{aq})$ .

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).



(ii) Complete the ionic equation for the reaction at the positive electrode (anode).



(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

..... [1]

(b) (i) Why does the water supply industry use chlorine?

..... [1]

(ii) Name an important chemical that is made from hydrogen.

..... [1]

(iii) Sodium hydroxide reacts with fats to make soap and glycerine  
What type of compound are fats?

..... [1]

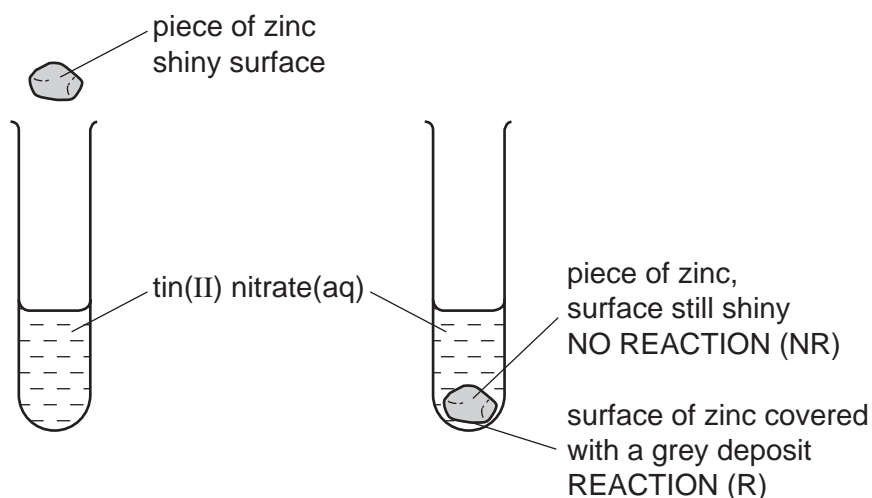
What type of the reaction is this?

..... [1]

[Total : 7]

6 The reactivity series lists metals in order of reactivity.

- (a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out.



This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

- (i) The order was found to be:
- |           |                |
|-----------|----------------|
| manganese | most reactive  |
| zinc      |                |
| tin       |                |
| silver    | least reactive |

Complete the table of results from which this order was determined.

aqueous solution	tin Sn	manganese Mn	silver Ag	zinc Zn
tin(II) nitrate		R	NR	R
manganese(II) nitrate				
silver(I) nitrate				
zinc nitrate				

[3]

- (ii) Write the equation for the reaction between zinc and silver(I) nitrate.

.....

[2]

For  
Examiner's  
Use

(iii) The following is a redox reaction.



Indicate on the equation which reagent is the oxidant or oxidizing agent.  
Give a reason for your choice.

..... [2]

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

.....  
..... [2]

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges,  $\text{K}^+$  and  $\text{Ca}^{2+}$ , their compounds behave differently when heated.

(i) Explain why the ions have different charges.

.....  
..... [2]

(ii) Their hydroxides are heated.  
If the compound decomposes, complete the word equation.  
If it does not decompose, write "no reaction".

Potassium hydroxide  $\longrightarrow$  .....

Calcium hydroxide  $\longrightarrow$  ..... [2]

(iii) Complete the equations for the decomposition of their nitrates.



[Total: 17]

- 7 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

For  
Examiner's  
Use

(a) The complete combustion of an alkane gives carbon dioxide and water.

- (i) 20 cm<sup>3</sup> of butane is mixed with 150 cm<sup>3</sup> of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?



Volume of oxygen left = ..... cm<sup>3</sup>

Volume of carbon dioxide formed = ..... cm<sup>3</sup> [2]

- (ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....  
..... [2]

(b) The equation for a substitution reaction of butane is given below.



- (i) Name the organic product.

..... [1]

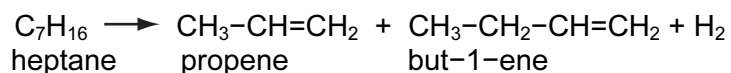
- (ii) This reaction does not need increased temperature or pressure. What is the essential reaction condition?

..... [1]

- (iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

- (c) Alkenes are more reactive and industrially more useful than alkanes.  
They are made by cracking alkanes.



- (i) Draw the structural formula of the polymer poly(propene).

[2]

- (ii) Give the structural formula and name of the alcohol formed when propene reacts with steam.

name .....

[1]

structural formula

[1]

- (iii) Deduce the structural formula of the product formed when but-1-ene reacts with hydrogen chloride.

[1]

[Total: 12]

For  
Examiner's  
Use



**DATA SHEET**  
**The Periodic Table of the Elements**

		Group																																																																																				
I	II	III	IV	V	VI	VII	0					0																																																																										
1 <b>H</b> Hydrogen 1											2 <b>He</b> Helium 2																																																																											
3 <b>Li</b> Lithium 3	4 <b>Be</b> Beryllium 4	5 <b>B</b> Boron 5	6 <b>C</b> Carbon 6	7 <b>N</b> Nitrogen 7	8 <b>O</b> Oxygen 8	9 <b>F</b> Fluorine 9	10 <b>Ne</b> Neon 10	11 <b>B</b> Boron 11	12 <b>C</b> Carbon 12	13 <b>Al</b> Aluminium 13	14 <b>Si</b> Silicon 14	15 <b>P</b> Phosphorus 15	16 <b>S</b> Sulphur 16	17 <b>Cl</b> Chlorine 17	18 <b>Ar</b> Argon 18																																																																							
19 <b>K</b> Potassium 19	20 <b>Ca</b> Calcium 20	21 <b>Sc</b> Scandium 21	22 <b>Ti</b> Titanium 22	23 <b>V</b> Vanadium 23	24 <b>Cr</b> Chromium 24	25 <b>Mn</b> Manganese 25	26 <b>Fe</b> Iron 26	27 <b>Co</b> Cobalt 27	28 <b>Ni</b> Nickel 28	29 <b>Cu</b> Copper 29	30 <b>Zn</b> Zinc 30	31 <b>Ga</b> Gallium 31	32 <b>Ge</b> Germanium 32	33 <b>As</b> Arsenic 33	34 <b>Se</b> Selenium 34	35 <b>Br</b> Bromine 35	36 <b>Kr</b> Krypton 36																																																																					
37 <b>Rb</b> Rubidium 37	38 <b>Sr</b> Strontium 38	39 <b>Y</b> Yttrium 39	40 <b>Zr</b> Zirconium 40	41 <b>Nb</b> Niobium 41	42 <b>Mo</b> Molybdenum 42	43 <b>Tc</b> Technetium 43	44 <b>Ru</b> Ruthenium 44	45 <b>Rh</b> Rhodium 45	46 <b>Pd</b> Palladium 46	47 <b>Ag</b> Silver 47	48 <b>Cd</b> Cadmium 48	49 <b>In</b> Indium 49	50 <b>Sn</b> Tin 50	51 <b>Sb</b> Antimony 51	52 <b>Te</b> Tellurium 52	53 <b>I</b> Iodine 53	54 <b>Xe</b> Xenon 54																																																																					
55 <b>Cs</b> Caesium 55	56 <b>Ba</b> Barium 56	57 <b>La</b> Lanthanum 57	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																																																					
87 <b>Fr</b> Francium 87	88 <b>Ra</b> Radium 88	89 <b>Ac</b> Actinium 89											103 <b>Lr</b> Lawrencium 103																																																																									
													100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																																						
													98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																																				
													96 <b>Cm</b> Curium 96	97 <b>Bk</b> Berkelium 97	98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																																		
													95 <b>Am</b> Americium 95	96 <b>Cm</b> Curium 96	97 <b>Bk</b> Berkelium 97	98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																																	
													93 <b>Np</b> Neptunium 93	94 <b>Pu</b> Plutonium 94	95 <b>Am</b> Americium 95	96 <b>Cm</b> Curium 96	97 <b>Bk</b> Berkelium 97	98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																															
													91 <b>Pa</b> Protactinium 91	92 <b>U</b> Uranium 92	93 <b>Np</b> Neptunium 93	94 <b>Pu</b> Plutonium 94	95 <b>Am</b> Americium 95	96 <b>Cm</b> Curium 96	97 <b>Bk</b> Berkelium 97	98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																													
													89 <b>Pr</b> Praseodymium 89	90 <b>Th</b> Thorium 90	91 <b>Pa</b> Protactinium 91	92 <b>U</b> Uranium 92	93 <b>Np</b> Neptunium 93	94 <b>Pu</b> Plutonium 94	95 <b>Am</b> Americium 95	96 <b>Cm</b> Curium 96	97 <b>Bk</b> Berkelium 97	98 <b>Cf</b> Californium 98	99 <b>Es</b> Einsteinium 99	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103																																																											
													61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																																
													60 <b>Nd</b> Neodymium 60	61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																															
													59 <b>Pr</b> Praseodymium 59	60 <b>Nd</b> Neodymium 60	61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																														
													49 <b>In</b> Indium 49	50 <b>Sn</b> Tin 50	51 <b>Sb</b> Antimony 51	52 <b>Te</b> Tellurium 52	53 <b>I</b> Iodine 53	54 <b>Xe</b> Xenon 54	55 <b>Cs</b> Caesium 55	56 <b>Ba</b> Barium 56	57 <b>La</b> Lanthanum 57	58 <b>Ce</b> Cerium 58	59 <b>Pr</b> Praseodymium 59	60 <b>Nd</b> Neodymium 60	61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																				
													47 <b>Ag</b> Silver 47	48 <b>Cd</b> Cadmium 48	49 <b>In</b> Indium 49	50 <b>Sn</b> Tin 50	51 <b>Sb</b> Antimony 51	52 <b>Te</b> Tellurium 52	53 <b>I</b> Iodine 53	54 <b>Xe</b> Xenon 54	55 <b>Cs</b> Caesium 55	56 <b>Ba</b> Barium 56	57 <b>La</b> Lanthanum 57	58 <b>Ce</b> Cerium 58	59 <b>Pr</b> Praseodymium 59	60 <b>Nd</b> Neodymium 60	61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Hf</b> Hafnium 72	73 <b>Ta</b> Tantalum 73	74 <b>W</b> Tungsten 74	75 <b>Re</b> Rhenium 75	76 <b>Os</b> Osmium 76	77 <b>Ir</b> Iridium 77	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	81 <b>Tl</b> Thallium 81	82 <b>Pb</b> Lead 82	83 <b>Bi</b> Bismuth 83	84 <b>Po</b> Polonium 84	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																		
													45 <b>Sc</b> Scandium 45	46 <b>Ti</b> Titanium 46	47 <b>V</b> Vanadium 47	48 <b>Cr</b> Chromium 48	49 <b>Mn</b> Manganese 49	50 <b>Fe</b> Iron 50	51 <b>Co</b> Cobalt 51	52 <b>Ni</b> Nickel 52	53 <b>Cu</b> Copper 53	54 <b>Zn</b> Zinc 54	55 <b>Ga</b> Gallium 55	56 <b>Ge</b> Germanium 56	57 <b>As</b> Arsenic 57	58 <b>Se</b> Selenium 58	59 <b>Br</b> Bromine 59	60 <b>Kr</b> Krypton 60	61 <b>Rb</b> Rubidium 61	62 <b>Sr</b> Strontium 62	63 <b>Y</b> Yttrium 63	64 <b>Zr</b> Zirconium 64	65 <b>Nb</b> Niobium 65	66 <b>Mo</b> Molybdenum 66	67 <b>Tc</b> Technetium 67	68 <b>Ru</b> Ruthenium 68	69 <b>Rh</b> Rhodium 69	70 <b>Pd</b> Palladium 70	71 <b>Ag</b> Silver 71	72 <b>Cd</b> Cadmium 72	73 <b>In</b> Indium 73	74 <b>Sn</b> Tin 74	75 <b>Sb</b> Antimony 75	76 <b>Te</b> Tellurium 76	77 <b>I</b> Iodine 77	78 <b>Xe</b> Xenon 78	79 <b>Cs</b> Caesium 79	80 <b>Ba</b> Barium 80	81 <b>La</b> Lanthanum 81	82 <b>Ce</b> Cerium 82	83 <b>Pr</b> Praseodymium 83	84 <b>Nd</b> Neodymium 84	85 <b>Pm</b> Promethium 85	86 <b>Sm</b> Samarium 86	87 <b>Eu</b> Europium 87	88 <b>Gd</b> Gadolinium 88	89 <b>Tb</b> Terbium 89	90 <b>Dy</b> Dysprosium 90	91 <b>Ho</b> Holmium 91	92 <b>Er</b> Erbium 92	93 <b>Tm</b> Thulium 93	94 <b>Yb</b> Ytterbium 94	95 <b>Lu</b> Lutetium 95	96 <b>Hf</b> Hafnium 96	97 <b>Ta</b> Tantalum 97	98 <b>W</b> Tungsten 98	99 <b>Re</b> Rhenium 99	100 <b>Os</b> Osmium 100	101 <b>Ir</b> Iridium 101	102 <b>Pt</b> Platinum 102	103 <b>Au</b> Gold 103	104 <b>Hg</b> Mercury 104	105 <b>Tl</b> Thallium 105	106 <b>Pb</b> Lead 106	107 <b>Bi</b> Bismuth 107	108 <b>Po</b> Polonium 108	109 <b>At</b> Astatine 109	110 <b>Rn</b> Radon 110								
													43 <b>Al</b> Aluminium 43	44 <b>Si</b> Silicon 44	45 <b>P</b> Phosphorus 45	46 <b>S</b> Sulphur 46	47 <b>Cl</b> Chlorine 47	48 <b>Ar</b> Argon 48	49 <b>K</b> Potassium 49	50 <b>Ca</b> Calcium 50	51 <b>Sc</b> Scandium 51	52 <b>Ti</b> Titanium 52	53 <b>V</b> Vanadium 53	54 <b>Cr</b> Chromium 54	55 <b>Mn</b> Manganese 55	56 <b>Fe</b> Iron 56	57 <b>Co</b> Cobalt 57	58 <b>Ni</b> Nickel 58	59 <b>Cu</b> Copper 59	60 <b>Zn</b> Zinc 60	61 <b>Ga</b> Gallium 61	62 <b>Ge</b> Germanium 62	63 <b>As</b> Arsenic 63	64 <b>Se</b> Selenium 64	65 <b>Br</b> Bromine 65	66 <b>Kr</b> Krypton 66	67 <b>Rb</b> Rubidium 67	68 <b>Sr</b> Strontium 68	69 <b>Y</b> Yttrium 69	70 <b>Zr</b> Zirconium 70	71 <b>Nb</b> Niobium 71	72 <b>Mo</b> Molybdenum 72	73 <b>Tc</b> Technetium 73	74 <b>Ru</b> Ruthenium 74	75 <b>Rh</b> Rhodium 75	76 <b>Pd</b> Palladium 76	77 <b>Ag</b> Silver 77	78 <b>Cd</b> Cadmium 78	79 <b>In</b> Indium 79	80 <b>Sn</b> Tin 80	81 <b>Sb</b> Antimony 81	82 <b>Te</b> Tellurium 82	83 <b>I</b> Iodine 83	84 <b>Xe</b> Xenon 84	85 <b>Cs</b> Caesium 85	86 <b>Ba</b> Barium 86	87 <b>La</b> Lanthanum 87	88 <b>Ce</b> Cerium 88	89 <b>Pr</b> Praseodymium 89	90 <b>Nd</b> Neodymium 90	91 <b>Pm</b> Promethium 91	92 <b>Sm</b> Samarium 92	93 <b>Eu</b> Europium 93	94 <b>Gd</b> Gadolinium 94	95 <b>Tb</b> Terbium 95	96 <b>Dy</b> Dysprosium 96	97 <b>Ho</b> Holmium 97	98 <b>Er</b> Erbium 98	99 <b>Tm</b> Thulium 99	100 <b>Yb</b> Ytterbium 100	101 <b>Lu</b> Lutetium 101	102 <b>Hf</b> Hafnium 102	103 <b>Ta</b> Tantalum 103	104 <b>W</b> Tungsten 104	105 <b>Re</b> Rhenium 105	106 <b>Os</b> Osmium 106	107 <b>Ir</b> Iridium 107	108 <b>Pt</b> Platinum 108	109 <b>Au</b> Gold 109	110 <b>Hg</b> Mercury 110	111 <b>Tl</b> Thallium 111	112 <b>Pb</b> Lead 112	113 <b>Bi</b> Bismuth 113	114 <b>Po</b> Polonium 114	115 <b>At</b> Astatine 115	116 <b>Rn</b> Radon 116
													41 <b>Al</b> Aluminium 41	42 <b>Si</b> Silicon 42	43 <b>P</b> Phosphorus 43	44 <b>S</b> Sulphur 44	45 <b>Cl</b> Chlorine 45	46 <b>Ar</b> Argon 46	47 <b>K</b> Potassium 47	48 <b>Ca</b> Calcium 48	49 <b>Sc</b> Scandium 49	50 <b>Ti</b> Titanium 50	51 <b>V</b> Vanadium 51	52 <b>Cr</b> Chromium 52	53 <b>Mn</b> Manganese 53	54 <b>Fe</b> Iron 54	55 <b>Co</b> Cobalt 55	56 <b>Ni</b> Nickel 56	57 <b>Cu</b> Copper 57	58 <b>Zn</b> Zinc 58	59 <b>Ga</b> Gallium 59	60 <b>Ge</b> Germanium 60	61 <b>As</b> Arsenic 61	62 <b>Se</b> Selenium 62	63 <b>Br</b> Bromine 63	64 <b>Kr</b> Krypton 64	65 <b>Rb</b> Rubidium 65	66 <b>Sr</b> Strontium 66	67 <b>Y</b> Yttrium 67	68 <b>Zr</b> Zirconium 68	69 <b>Nb</b> Niobium 69	70 <b>Mo</b> Molybdenum 70	71 <b>Tc</b> Technetium 71	72 <b>Ru</b> Ruthenium 72	73 <b>Rh</b> Rhodium 73	74 <b>Pd</b> Palladium 74																																								