

## 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.

<b>Question Paper</b>	<b>Mark Scheme</b>	<b>Principal Examiner's Report</b>
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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\* 7 1 9 0 2 5 0 8 2 4 \*

**CHEMISTRY**

Paper 3 (Extended)

**0620/31**

**May/June 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	
8	
<b>Total</b>	

This document consists of **11** printed pages and **1** blank page.



1 For each of the following select an element from Period 4, potassium to krypton, that matches the description.

For  
Examiner's  
Use

(a) It is a brown liquid at room temperature. ....

(b) It forms a compound with hydrogen having the formula  $XH_4$ . ....

(c) A metal that reacts violently with cold water. ....

(d) It has a complete outer energy level. ....

(e) It has oxidation states of 2 and 3 only. ....

(f) It can form an ion of the type  $X^-$ . ....

(g) One of its oxides is the catalyst in the Contact Process. ....

[Total: 7]

- 2 (a) Complete the table which gives the names, symbols, relative masses and relative charges of the three subatomic particles.

name	symbol	relative mass	relative charge
electron	$e^-$		
proton		1	
	n		0

[3]

- (b) Use the information in the table to explain the following.

- (i) Atoms contain charged particles but they are electrically neutral because they have no overall charge.

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

- (ii) Atoms can form positive ions.

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

- (iii) Atoms of the same element can have different masses.

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

- (iv) Scientists are certain that there are no undiscovered elements missing from the Periodic Table from hydrogen to lawrencium.

..... [1]

[Total: 10]

For  
Examiner's  
Use

3 Copper is purified by electrolysis.

(a) Complete the following.

The positive electrode (anode) is made from .....

The negative electrode (cathode) is made from .....

The electrolyte is aqueous ..... [3]

(b) Write an ionic equation for the reaction at the positive electrode (anode).

..... [2]

(c) (i) Give **two** reasons why copper is used,

in electric wiring, ..... [2]  
.....

in cooking utensils. .... [2]  
.....

(ii) Give another use of copper.

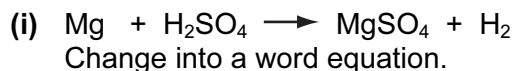
..... [1]

[Total: 10]

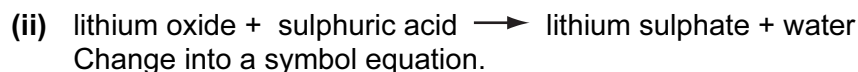
4 Sulphuric acid is a typical strong acid.

For  
Examiner's  
Use

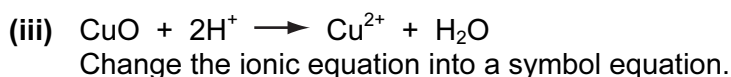
(a) Change the equations given into a different format.



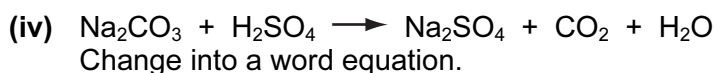
..... [1]



..... [2]

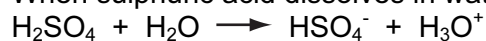


..... [2]



..... [1]

(b) When sulphuric acid dissolves in water, the following reaction occurs.



Explain why water is behaving as a base in this reaction.

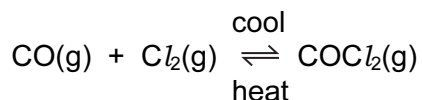
..... [2]

(c) Sulphuric acid is a strong acid, ethanoic acid is a weak acid.  
Explain the difference between a strong acid and a weak acid.

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

[Total: 10]

- 5 Carbonyl chloride,  $\text{COCl}_2$ , is a colourless gas. It is made by the following reaction.



For  
Examiner's  
Use

- (a) When the pressure on the equilibrium mixture is decreased, the position of equilibrium moves to left.

- (i) How does the concentration of each of the three chemicals change?

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

- (ii) Explain why the position of equilibrium moves to left.

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

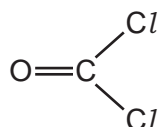
- (b) Using the information given with the equation, is the forward reaction exothermic or endothermic? Give a reason for your choice.

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

- (c) Carbonyl chloride reacts with water to form two acidic compounds. Suggest which acidic compounds are formed.

1. ....  
2. .... [2]

- (d) The structural formula of carbonyl chloride is given below.



Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.

Use x for an electron from a chlorine atom.

Use o for an electron from a carbon atom.

Use • for an electron from an oxygen atom.

[4]  
[Total: 12]

6 Three of the factors that can influence the rate of a chemical reaction are:

- physical state of the reactants
- light
- the presence of a catalyst

(a) The first recorded dust explosion was in a flour mill in Italy in 1785. Flour contains carbohydrates. Explosions are very fast exothermic reactions.

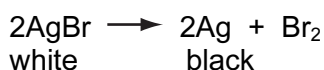
(i) Use the collision theory to explain why the reaction between the particles of flour and the oxygen in the air is very fast.

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

(ii) Write a word equation for this exothermic reaction.

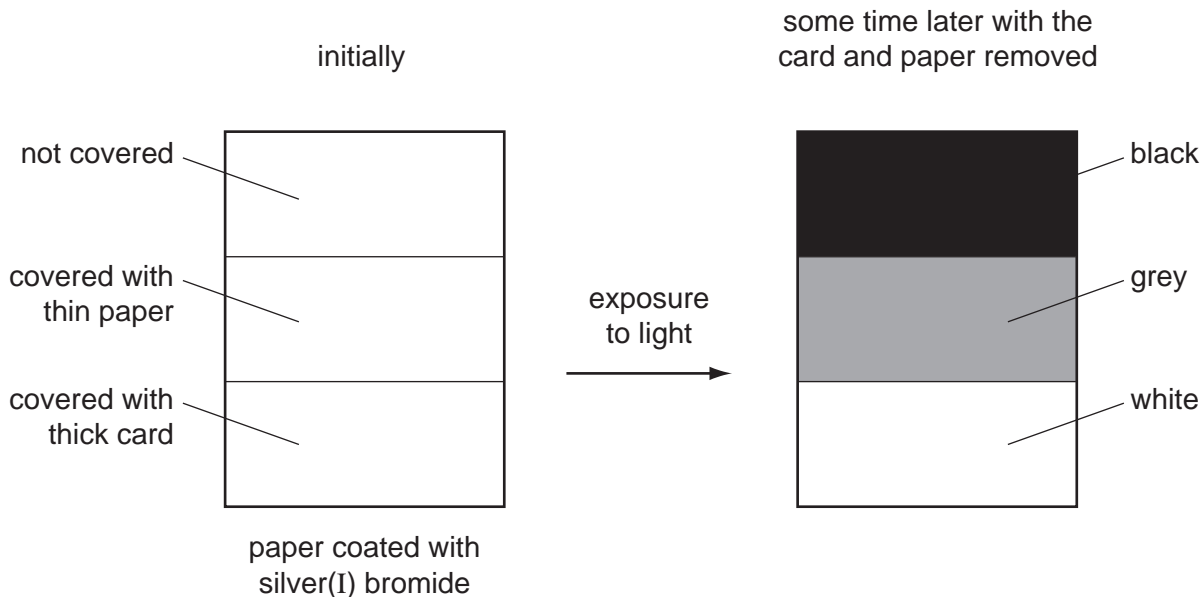
..... [1]

The decomposition of silver(I) bromide is the basis of film photography. The equation for this decomposition is:



This reaction is photochemical.

A piece of white paper was coated with silver(I) bromide and the following experiment was carried out.

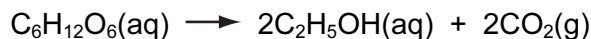


(b) Explain the results.

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



- (c) The fermentation of glucose is catalysed by enzymes from yeast. Yeast is added to aqueous glucose, the solution starts to bubble and becomes cloudy as more yeast cells are formed.



The reaction is exothermic.

Eventually the fermentation stops when the concentration of ethanol is about 12%.

- (i) What is an enzyme?

..... [1]

- (ii) Pasteur said that fermentation was respiration in the absence of air. Suggest a definition of *respiration*.

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

- (iii) On a large scale, the reaction mixture is cooled. Suggest a reason why this is necessary.

..... [1]

- (iv) Why does the fermentation stop? Suggest **two** reasons.

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

- (v) When the fermentation stops, there is a mixture of dilute aqueous ethanol and yeast. Suggest a technique which could be used to remove the cloudiness due to the yeast.

..... [1]

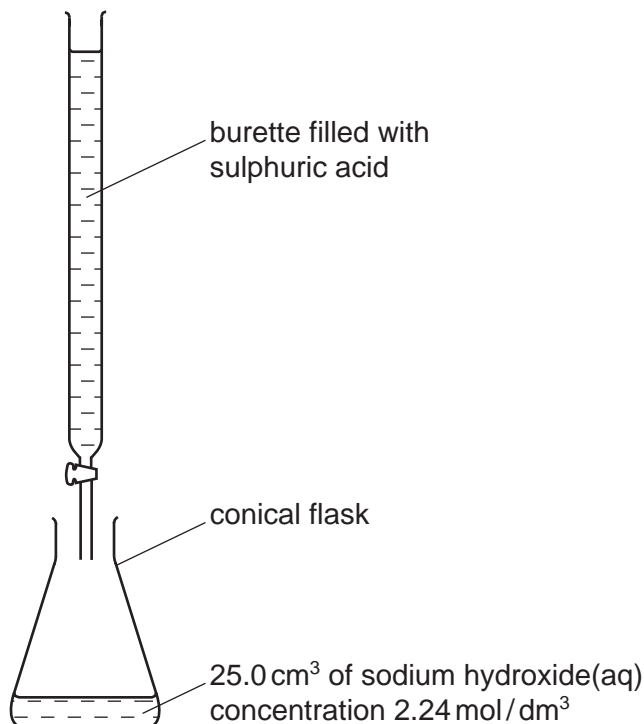
Name a technique which will separate the ethanol from the ethanol/water mixture.

..... [1]

[Total: 14]

7 Crystals of sodium sulphate-10-water,  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ , are prepared by titration.

For  
Examiner's  
Use



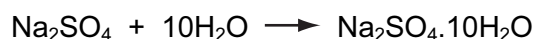
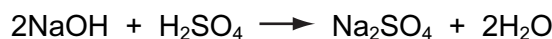
- (a)  $25.0 \text{ cm}^3$  of aqueous sodium hydroxide is pipetted into a conical flask. A few drops of an indicator are added. Using a burette, dilute sulphuric acid is slowly added until the indicator just changes colour. The volume of acid needed to neutralise the alkali is noted.

Suggest how you would continue the experiment to obtain pure, dry crystals of sodium sulphate-10-water.

.....  
 .....  
 .....

[4]

- (b) Using  $25.0 \text{ cm}^3$  of aqueous sodium hydroxide,  $2.24 \text{ mol / dm}^3$ ,  $3.86 \text{ g}$  of crystals were obtained. Calculate the percentage yield.



Number of moles of NaOH used = .....

Maximum number of moles of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  that could be formed = .....

Mass of one mole of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} = 322 \text{ g}$

Maximum yield of sodium sulphate-10-water = ..... g

Percentage yield = ..... % [4]

[Total: 8]

8 Large areas of the Amazon rain forest are cleared each year to grow soya beans. The trees are cut down and burnt.

(a) Why do these activities increase the percentage of carbon dioxide in the atmosphere?

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

(b) Soya beans contain all three main food groups. Two of which are protein and carbohydrate.

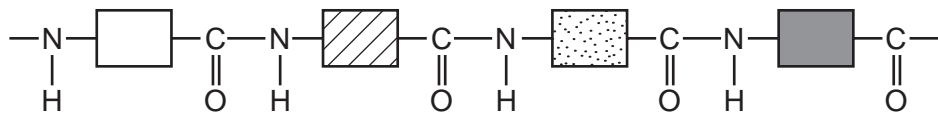
(i) What is the third group?

..... [1]

(ii) Draw the structural formula of a complex carbohydrate such as starch.

[3]

(iii) Compare the structure of a protein with that of a synthetic polyamide. The structure of a typical protein is given below.



How are they similar?

.....

How are they different?

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

[Total: 9]

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

		Group																				
		I	II	III	IV	V	VI	VII	0													
				<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td style="width: 12.5%;">1 <b>H</b> Hydrogen 1</td> <td colspan="7"></td> <td style="width: 12.5%;">4 <b>He</b> Helium 2</td> </tr> </table>								1 <b>H</b> Hydrogen 1								4 <b>He</b> Helium 2		
1 <b>H</b> Hydrogen 1								4 <b>He</b> Helium 2														
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4									11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	14 <b>N</b> Nitrogen 7	16 <b>O</b> Oxygen 8	19 <b>F</b> Fluorine 9	20 <b>Ne</b> Neon 10							
23 <b>Na</b> Sodium 11	24 <b>Mg</b> Magnesium 12									27 <b>Al</b> Aluminium 13	28 <b>Si</b> Silicon 14	31 <b>P</b> Phosphorus 15	32 <b>S</b> Sulphur 16	35.5 <b>Cl</b> Chlorine 17	40 <b>Ar</b> Argon 18							
39 <b>K</b> Potassium 19	40 <b>Ca</b> Calcium 20									70 <b>Ga</b> Gallium 31	73 <b>Ge</b> Germanium 32	75 <b>As</b> Arsenic 33	79 <b>Se</b> Selenium 34	80 <b>Br</b> Bromine 35	84 <b>Kr</b> Krypton 36							
85 <b>Rb</b> Rubidium 37	88 <b>Sr</b> Strontium 38									64 <b>Cu</b> Copper 29	65 <b>Zn</b> Zinc 30	106 <b>Pd</b> Palladium 46	108 <b>Ag</b> Silver 47	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	122 <b>Sb</b> Antimony 51	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54				
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56									59 <b>Ni</b> Nickel 28	59 <b>Co</b> Cobalt 27	103 <b>Rh</b> Rhodium 45	105 <b>Pt</b> Platinum 78	197 <b>Au</b> Gold 79	201 <b>Hg</b> Mercury 80	209 <b>Bi</b> Bismuth 83	210 <b>Po</b> Polonium 84	222 <b>Rn</b> Radon 86				
226 <b>Fr</b> Francium 87	227 <b>Ra</b> Radium 88									51 <b>V</b> Vanadium 23	52 <b>Cr</b> Chromium 24	93 <b>Nb</b> Niobium 41	94 <b>Ta</b> Tantalum 73	181 <b>Hf</b> Hafnium 72	182 <b>W</b> Tungsten 74	186 <b>Re</b> Rhenium 75	190 <b>Os</b> Osmium 76	192 <b>Ir</b> Iridium 77	195 <b>Pt</b> Platinum 78	201 <b>Hg</b> Mercury 80		
										55 <b>Mn</b> Manganese 25	56 <b>Fe</b> Iron 26	101 <b>Ru</b> Ruthenium 44	101 <b>Ru</b> Ruthenium 44	106 <b>Pd</b> Palladium 46	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	122 <b>Sb</b> Antimony 51	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54			
										140 <b>Ce</b> Cerium 58	141 <b>Pr</b> Praseodymium 59	144 <b>Nd</b> Neodymium 60	150 <b>Sm</b> Samarium 62	152 <b>Eu</b> Europium 63	157 <b>Gd</b> Gadolinium 64	162 <b>Dy</b> Dysprosium 66	165 <b>Ho</b> Holmium 67	167 <b>Er</b> Erbium 68	173 <b>Yb</b> Ytterbium 70	175 <b>Lu</b> Lutetium 71		
										232 <b>Th</b> Thorium 90	232 <b>Th</b> Thorium 90	238 <b>U</b> Uranium 92	238 <b>U</b> Uranium 92	294 <b>Cm</b> Curium 96	294 <b>Cm</b> Curium 96	100 <b>Fm</b> Fermium 100	101 <b>Md</b> Mendelevium 101	102 <b>No</b> Nobelium 102	103 <b>Lr</b> Lawrencium 103			

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

	<b>a</b>	<b>X</b>	<b>b</b>
<b>Key</b>	a = relative atomic mass	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.).

Second Variant Question Paper



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER 

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CANDIDATE NUMBER 

--	--	--	--

\* 8 6 7 2 1 8 2 5 5 2 \*

**CHEMISTRY**

**0620/32**

Paper 3 (Extended)

**May/June 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	
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7	
8	
<b>Total</b>	

This document consists of **11** printed pages and **1** blank page.



1 For each of the following select an element from Period 4, potassium to krypton, that matches the description.

*For  
Examiner's  
Use*

(a) It is a brown liquid at room temperature.

.....

(b) It forms a covalent compound with hydrogen having the formula  $H_2X$ .

.....

(c) A metal that reacts violently with cold water.

.....

(d) It has a complete outer energy level.

.....

(e) It has oxidation states of 2 and 3 only.

.....

(f) It can form an ion of the type  $X^+$ .

.....

(g) This metal is the catalyst in the Haber Process.

.....

[Total: 7]

- 2 (a) Complete the table which gives the names, symbols, relative masses and relative charges of the three subatomic particles.

For  
Examiner's  
Use

name	symbol	relative mass	relative charge
electron	$e^-$		
proton		1	
neutron	n		

[3]

- (b) Use the information in the table to explain the following.

- (i) Atoms contain charged particles but they are electrically neutral - they have no overall charge.

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

- (ii) Atoms can form negative ions.

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

- (iii) Different atoms of the element chlorine are  $^{35}_{17}\text{Cl}$  and  $^{37}_{17}\text{Cl}$ .

How are they different? .....

How are they the same? ..... [2]

- (iv) Scientists are certain that there are no undiscovered elements missing from the Periodic Table from hydrogen to lawrencium.

..... [1]

[Total: 10]



3 Copper is purified by electrolysis.

(a) Complete the following.

The positive electrode (anode) is made from .....

The negative electrode (cathode) is made from .....

The electrolyte is aqueous ..... [3]

(b) Write an ionic equation for the reaction at the positive electrode (anode).

..... [2]

(c) (i) Give **two** reasons why copper is used,

in electric wiring, ..... [2]  
.....

in cooking utensils. .... [2]  
.....

(ii) Give another use of copper.

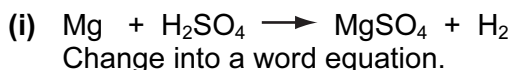
..... [1]

[Total: 10]

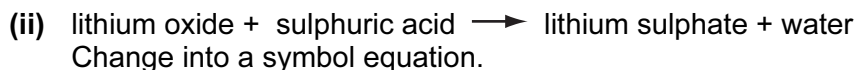
4 Sulphuric acid is a typical strong acid.

For  
Examiner's  
Use

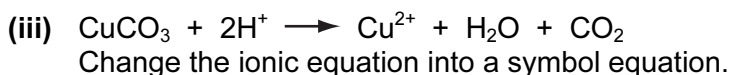
(a) Change the equation given into a different format.



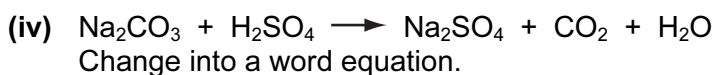
..... [1]



..... [2]

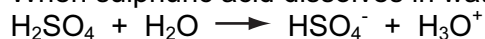


..... [2]



..... [1]

(b) When sulphuric acid dissolves in water, the following reaction occurs.



Explain why water is behaving as a base.

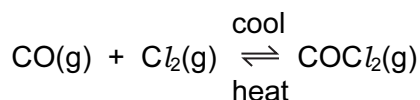
..... [2]

(c) Sulphuric acid is a strong acid, ethanoic acid is a weak acid. One way of distinguishing between them is to measure their pH. The weaker acid will have the higher pH. Describe another way by which they could be distinguished.

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

[Total: 10]

- 5 Carbonyl chloride,  $\text{COCl}_2$ , is a colourless gas. It is made by the following reaction.



For  
Examiner's  
Use

- (a) When the pressure on the equilibrium mixture is increased, the position of equilibrium moves to right.

- (i) How does the concentration of each of the three chemicals change?

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

- (ii) Explain why the position of equilibrium moves to right.

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

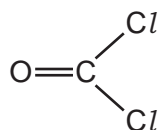
- (b) Using the information given with the equation, is the forward reaction exothermic or endothermic? Give a reason for your choice.

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

- (c) Carbonyl chloride reacts with water to form two acidic compounds. Name them.

..... [2]

- (d) The structural formula of carbonyl chloride is given below.



Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.

Use x for an electron from a chlorine atom.

Use o for an electron from a carbon atom.

Use • for an electron from an oxygen atom.

[4]  
[Total: 12]

6 Three of the factors that can influence the rate of a chemical reaction are:

- physical state of the reactants
- light
- the presence of a catalyst

(a) The first recorded dust explosion was in a flour mill in Italy in 1785. Flour contains carbohydrates. Explosions are very fast exothermic reactions.

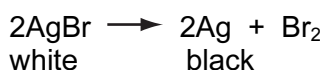
(i) Use the collision theory to explain why the reaction between the particles of flour and the oxygen in the air is very fast.

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

(ii) Write a word equation for this exothermic reaction.

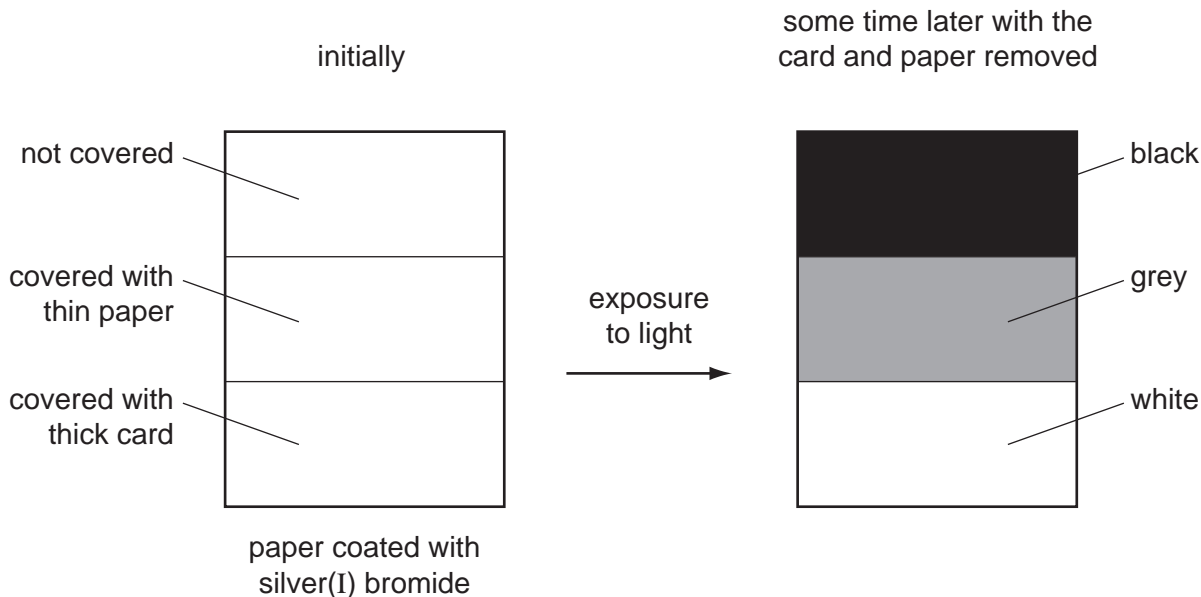
..... [1]

The decomposition of silver(I) bromide is the basis of film photography. The equation for this decomposition is:



(b) This reaction is photochemical.

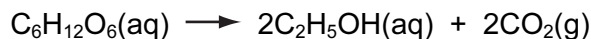
A piece of white paper was coated with silver(I) bromide and the following experiment was carried out.



Explain the results.

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

- (c) The fermentation of glucose is catalysed by enzymes from yeast. Yeast is added to aqueous glucose, the solution starts to bubble and becomes cloudy as more yeast cells are formed.



The reaction is exothermic.

Eventually the fermentation stops when the concentration of ethanol is about 12%.

- (i) What is an enzyme?

..... [1]

- (ii) Pasteur said that fermentation was respiration in the absence of air. Define *respiration*.

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

- (iii) On a large scale, the reaction mixture is cooled. Suggest a reason why this is necessary.

..... [1]

- (iv) Why does the fermentation stop? Suggest **two** reasons.

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

- (v) When the fermentation stops, there is a mixture of dilute aqueous ethanol and yeast. Suggest a technique which could be used to remove the cloudiness due to the yeast.

..... [1]

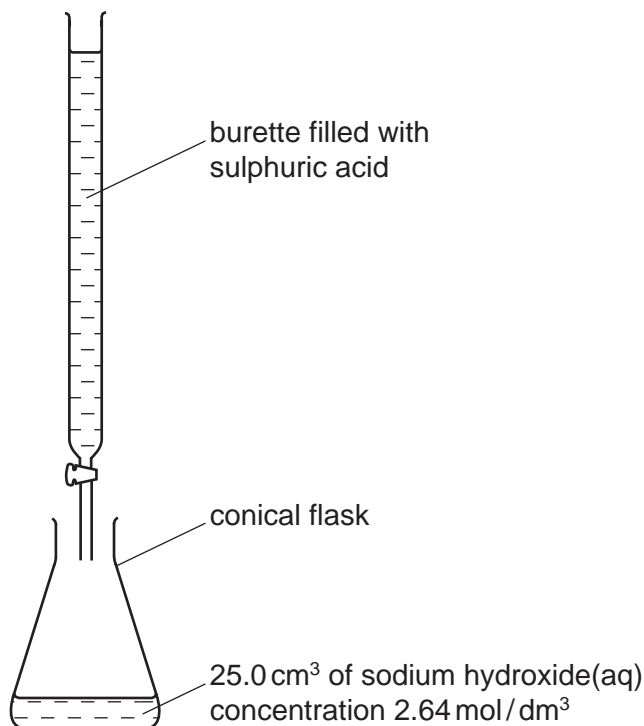
Name another technique which will separate the ethanol from the ethanol / water mixture.

..... [1]

[Total: 14]

7 Crystals of sodium sulphate-10-water,  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ , are prepared by titration.

For  
Examiner's  
Use



- (a)  $25.0 \text{ cm}^3$  of aqueous sodium hydroxide is pipetted into a conical flask. A few drops of an indicator are added. Using a burette, dilute sulphuric acid is slowly added until the indicator just changes colour. The volume of acid needed to neutralise the alkali is noted.

Suggest how you would continue the experiment to obtain pure, dry crystals of sodium sulphate-10-water.

.....  
 .....  
 .....

[4]

- (b) Using  $25.0 \text{ cm}^3$  of aqueous sodium hydroxide,  $2.64 \text{ mol / dm}^3$ ,  $3.95 \text{ g}$  of crystals were obtained. Calculate the percentage yield.



Number of moles of NaOH used = .....

Maximum number of moles of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  that could be formed = .....

Mass of one mole of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} = 322 \text{ g}$

Maximum yield of sodium sulphate-10-water = ..... g

Percentage yield = ..... % [4]

[Total: 8]

8 Large areas of the Amazon rain forest are cleared each year to grow soya beans. The trees are cut down and burnt.

(a) Why do these activities increase the percentage of carbon dioxide in the atmosphere?

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

(b) Soya beans contain all three main food groups. Two of which are protein and carbohydrate.

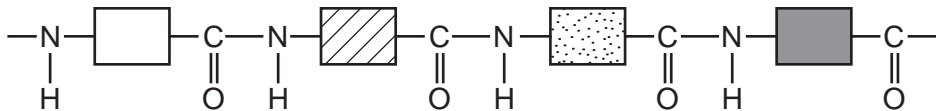
(i) What is the third group?

..... [1]

(ii) Draw the structural formula of a complex carbohydrate such as starch.

[3]

(iii) Compare the structure of a protein with that of a synthetic polyamide. The structure of a typical protein is given below.



How are they similar?

.....

How are they different?

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

[Total: 9]

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

		Group														
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	O				
		1 <b>H</b> Hydrogen 1														
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4											4 <b>He</b> Helium 2				
23 <b>Na</b> Sodium 11	24 <b>Mg</b> Magnesium 12											19 <b>F</b> Fluorine 9				
39 <b>K</b> Potassium 19	40 <b>Ca</b> Calcium 20	51 <b>V</b> Vanadium 23	52 <b>Cr</b> Chromium 24	55 <b>Mn</b> Manganese 25	56 <b>Fe</b> Iron 26	59 <b>Co</b> Cobalt 27	59 <b>Ni</b> Nickel 28	64 <b>Cu</b> Copper 29	65 <b>Zn</b> Zinc 30	73 <b>Ge</b> Germanium 32	75 <b>As</b> Arsenic 33	79 <b>Se</b> Selenium 34	84 <b>Kr</b> Krypton 36			
85 <b>Rb</b> Rubidium 37	88 <b>Sr</b> Strontium 38	91 <b>Zr</b> Zirconium 40	96 <b>Mo</b> Molybdenum 42	101 <b>Ru</b> Ruthenium 44	106 <b>Pd</b> Palladium 46	108 <b>Ag</b> Silver 47	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	119 <b>Sn</b> Tin 50	122 <b>Sb</b> Antimony 51	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54				
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56	178 <b>Hf</b> Hafnium 72	184 <b>W</b> Tungsten 74	190 <b>Os</b> Osmium 76	195 <b>Pt</b> Platinum 78	197 <b>Au</b> Gold 79	201 <b>Hg</b> Mercury 80	204 <b>Tl</b> Thallium 81	207 <b>Pb</b> Lead 82	209 <b>Bi</b> Bismuth 83	210 <b>Po</b> Polonium 84	210 <b>At</b> Astatine 85	210 <b>Rn</b> Radon 86			
87 <b>Fr</b> Francium	226 <b>Ra</b> Radium	227 <b>Ac</b> Actinium †														
*58-71 Lanthanoid series													175 <b>Lu</b> Lutetium 71			
†90-103 Actinoid series													102 <b>No</b> Nobelium 102			
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td style="width: 5%; text-align: left;">a</td> <td style="width: 5%; text-align: center;"><b>X</b></td> <td style="width: 5%; text-align: right;">b</td> </tr> </table>													a	<b>X</b>	b	169 <b>Tm</b> Thulium 69
a	<b>X</b>	b														
<p>a = relative atomic mass X = atomic symbol b = proton (atomic) number</p>													167 <b>Er</b> Erbium 68			
<p>The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).</p>													166 <b>Dy</b> Dysprosium 66			
<p>140 <b>Ce</b> Cerium 58</p>													162 <b>Dy</b> Dysprosium 66			
<p>141 <b>Pr</b> Praseodymium 59</p>													159 <b>Tb</b> Terbium 65			
<p>144 <b>Nd</b> Neodymium 60</p>													157 <b>Gd</b> Gadolinium 64			
<p>150 <b>Sm</b> Samarium 62</p>													152 <b>Eu</b> Europium 63			
<p>152 <b>Eu</b> Europium 63</p>													152 <b>Eu</b> Europium 63			
<p>157 <b>Gd</b> Gadolinium 64</p>													157 <b>Gd</b> Gadolinium 64			
<p>162 <b>Dy</b> Dysprosium 66</p>													162 <b>Dy</b> Dysprosium 66			
<p>167 <b>Er</b> Erbium 68</p>													167 <b>Er</b> Erbium 68			
<p>169 <b>Tm</b> Thulium 69</p>													169 <b>Tm</b> Thulium 69			
<p>175 <b>Lu</b> Lutetium 71</p>													175 <b>Lu</b> Lutetium 71			
<p>232 <b>Th</b> Thorium 90</p>													232 <b>Th</b> Thorium 90			
<p>238 <b>U</b> Uranium 92</p>													238 <b>U</b> Uranium 92			
<p>91 <b>Pa</b> Protactinium 91</p>													91 <b>Pa</b> Protactinium 91			
<p>93 <b>Np</b> Neptunium 93</p>													93 <b>Np</b> Neptunium 93			
<p>94 <b>Pu</b> Plutonium 94</p>													94 <b>Pu</b> Plutonium 94			
<p>95 <b>Am</b> Americium 95</p>													95 <b>Am</b> Americium 95			
<p>96 <b>Cm</b> Curium 96</p>													96 <b>Cm</b> Curium 96			
<p>97 <b>Bk</b> Berkelium 97</p>													97 <b>Bk</b> Berkelium 97			
<p>99 <b>Es</b> Einsteinium 99</p>													99 <b>Es</b> Einsteinium 99			
<p>100 <b>Fm</b> Fermium 100</p>													100 <b>Fm</b> Fermium 100			
<p>101 <b>Md</b> Mendelevium 101</p>													101 <b>Md</b> Mendelevium 101			
<p>102 <b>No</b> Nobelium 102</p>													102 <b>No</b> Nobelium 102			
<p>103 <b>Lr</b> Lawrencium 103</p>													103 <b>Lr</b> Lawrencium 103			

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