Location Entry Codes

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

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.

First Variant Question Paper

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

5310297965

CHEMISTRY **0620/31**

Paper 3 (Extended) **May/June 2009**

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 16.

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	
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8	
9	
Total	

This document consists of **15** printed pages and **1** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

1 Some grass is crushed and mixed with the solvent, propanone. The colour pigme extracted to give a deep green solution.

(a) (i) Draw a labelled diagram to describe how you could show that there is more than one coloured pigment in the green solution.

[3]

(ii) Given a pure sample of chlorophyll, how could you show that the green solution from the grass contained chlorophyll?

.....

.....

.....

..... [2]

(b) Explain the role of chlorophyll in green plants.

.....

.....

.....

.....

.....

..... [3]

[Total: 8]

2 The results of experiments on electrolysis using inert electrodes are given in the table.

Complete the table; the first line has been completed as an example.

electrolyte	**change at negative electrode**	**change at positive electrode**	**change to electrolyte**
molten lead(II) bromide	lead formed	bromine formed	used up
....	potassium formed	iodine formed	used up
dilute aqueous sodium chloride	.....	.....	....
aqueous copper(II) sulfate	.....	.....	....
....	hydrogen formed	bromine formed	potassium hydroxide formed

[Total: 8]

3 The following is a list of the electron distributions of atoms of unknown elements.

element	electron distribution
A	2,5
B	2,8,4
C	2,8,8,2
D	2,8,18,8
E	2,8,18,8,1
F	2,8,18,18,7

(a) Choose an element from the list for each of the following descriptions.

(i) It is a noble gas. .....

(ii) It is a soft metal with a low density. .....

(iii) It can form a covalent compound with element **A**. .....

(iv) It has a giant covalent structure similar to diamond. .....

(v) It can form a negative ion of the type X^{3-}. ..... [5]

(b) Elements **C** and **F** can form an ionic compound.

(i) Draw a diagram that shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use **o** to represent an electron from an atom of **C**.
Use **x** to represent an electron from an atom of **F**.

[3]

(ii) Predict **two** properties of this compound.

.....

.....

..... [2]

[Total: 10]

4 The reactivity series of metals given below contains both familiar and unfamiliar ele
For most of the unfamiliar elements, which are marked *, their common oxidation states
given.

* barium	Ba
* lanthanum	La (+3)
magnesium	
zinc	
* chromium	Cr (+2), (+3), (+6)
iron	
copper	
* palladium	(+2)

Choose metal(s) from the above list to answer the following questions.

(i) Which **two** metals would not react with dilute hydrochloric acid?

..... [2]

(ii) Which **two** unfamiliar metals (*) would react with cold water?

..... [2]

(iii) What is the oxidation state of barium?

..... [1]

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

..... [1]

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

.....

..... [1]

[Total: 7]

5 Insoluble salts are made by precipitation.

(a) A preparation of the insoluble salt calcium fluoride is described below.

To 15 cm^3 of aqueous calcium chloride, 30 cm^3 of aqueous sodium fluoride is added. The concentration of both solutions is 1.00 mol / dm^3. The mixture is filtered and the precipitate washed with distilled water. Finally, the precipitate is heated in an oven.

(i) Complete the equation.

$$Ca^{2+} + \text{.....}F^- \longrightarrow \text{.....} \quad [2]$$

(ii) Why is the volume of sodium fluoride solution double that of the calcium chloride solution?

.....

..... [1]

(iii) Why is the mixture washed with distilled water?

.....

..... [1]

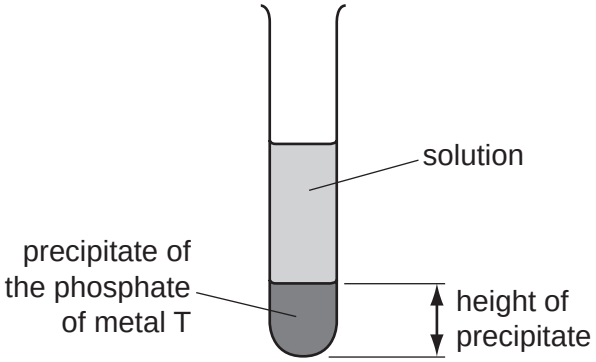
(iv) Why is the solid heated?

.....

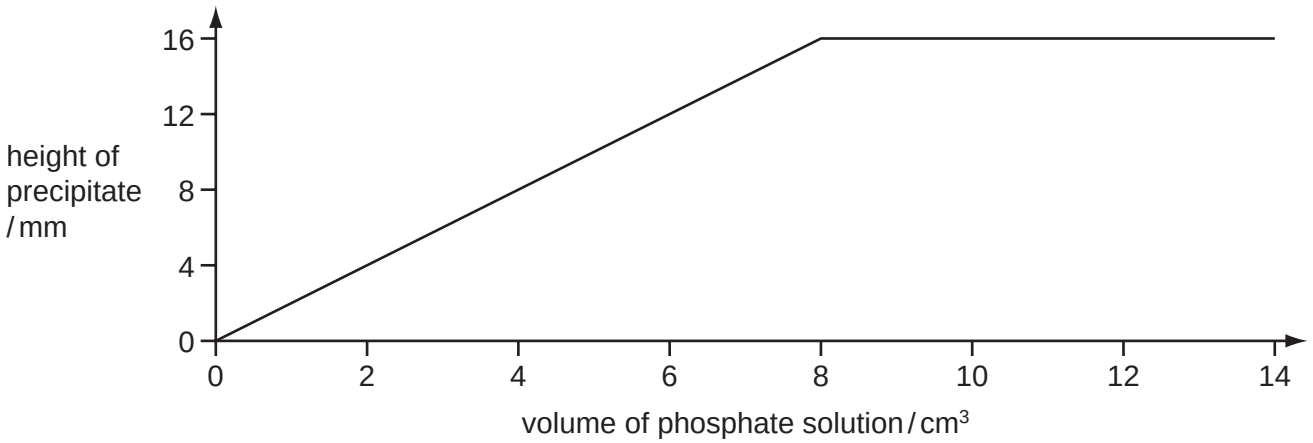
..... [1]

(b) The formulae of insoluble compounds can be found by precipitation reactions.

To 12.0 cm^3 of an aqueous solution of the nitrate of metal T was added 2.0 cm^3 of aqueous sodium phosphate, Na_3PO_4. The concentration of both solutions was 1.00 mol/dm^3. When the precipitate had settled, its height was measured.



The experiment was repeated using different volumes of the phosphate solution. The results are shown on the following graph.



What is the formula of the phosphate of metal T? Give your reasoning.

.....

.....

.....

..... [3]

[Total: 8]

6 Ammonia is manufactured by the Haber process.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ the forward reaction is exothermic

(a) (i) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen from ..... [1]

hydrogen from ..... [1]

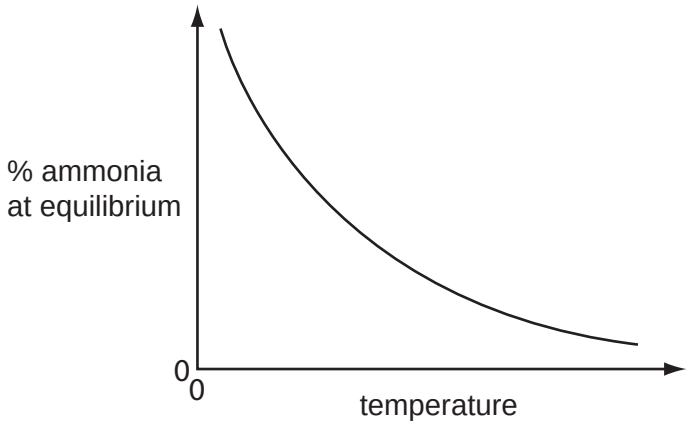
(ii) Name the catalyst used in this process.

..... [1]

(iii) What is the most important use of ammonia?

..... [1]

(b) The following graph shows how the percentage of ammonia in the equilibrium mixture changes with temperature.



(i) Explain the term *equilibrium*.

.....

.....

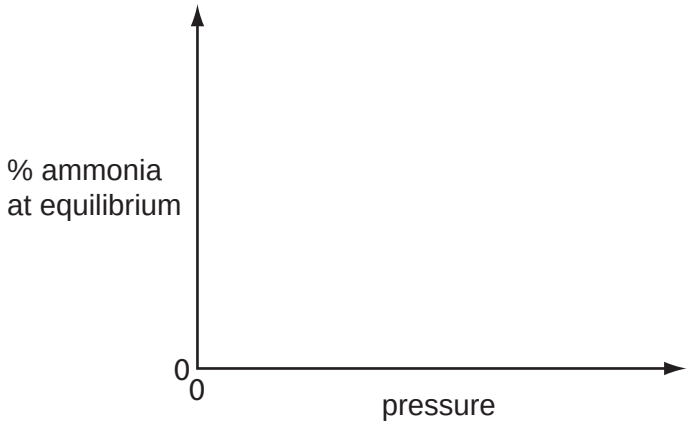
.....

..... [2]

(ii) How does the percentage of ammonia vary with temperature?

..... [1]

(c) (i) Sketch a graph which shows how the percentage of ammonia in the equi
mixture varies with pressure.



[1]

(ii) Explain why the graph has the shape shown.

.....

.....

..... [2]

[Total: 10]

7 Hydrogen reacts with the halogens to form hydrogen halides.

(a) Bond energy is the amount of energy, in kJ, that must be supplied (endothermic) to break one mole of a bond.

bond	bond energy in kJ / mol
H–H	+436
C*l*–C*l*	+242
H–C*l*	+431

Use the above data to show that the following reaction is exothermic.

$$H–H + Cl–Cl \rightarrow 2H–Cl$$

.....

.....

.....

.....

..... [3]

(b) They react with water to form acidic solutions.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$HF + H_2O \rightleftharpoons H_3O^+ + F^-$$

(i) Explain why water behaves as a base in both of these reactions.

.....

..... [2]

(ii) At equilibrium, only 1% of the hydrogen chloride exists as molecules, the rest has formed ions. In the other equilibrium, 97% of the hydrogen fluoride exists as molecules, only 3% has formed ions.

What does this tell you about the strength of each acid?

.....

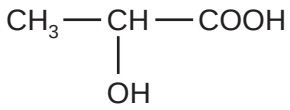
..... [2]

(iii) How would the pH of these two solutions differ?

..... [1]

[Total: 8]

8 Lactic acid can be made from corn starch.



lactic acid

It polymerises to form the polymer, polylactic acid (PLA) which is biodegradable.

(a) Suggest **two** advantages that PLA has compared with a polymer made from petroleum.

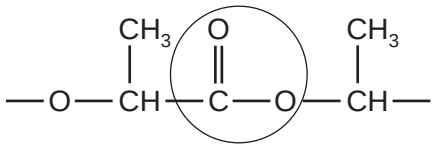
.....

.....

.....

..... [2]

(b) The structure of PLA is given below.



(i) What type of compound contains the group that is circled?

..... [1]

(ii) Complete the following sentence.

Lactic acid molecules can form this group because they contain both an

..... group and an ..... group. [2]

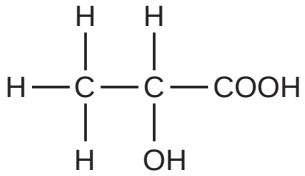
(iii) Is the formation of PLA, an addition or condensation polymerisation? Give a reason for your choice.

.....

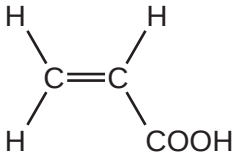
.....

..... [2]

(c) When lactic acid is heated, acrylic acid is formed.



lactic acid



acrylic acid

(i) Complete the word equation for the action of heat on lactic acid.

lactic acid → ..... + ... [1]

(ii) Describe a test that would distinguish between lactic acid and acrylic acid.

test .....

result for lactic acid .....

result for acrylic acid ..... [3]

(iii) Describe a test, other than using an indicator, which would show that both chemicals contain an acid group.

test .....

result .....

..... [2]

[Total: 13]

9 Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(a) A compound contains 72% magnesium and 28% nitrogen. What is its empirical formula?

.....

.....

.....

..... [2]

(b) A compound contains only aluminium and carbon. 0.03 moles of this compound reacted with excess water to form 0.12 moles of $Al(OH)_3$ and 0.09 moles of CH_4.

Write a balanced equation for this reaction.

.....

.....

.....

..... [2]

(c) 0.07 moles of silicon reacts with 25 g of bromine.

$$Si + 2Br_2 \longrightarrow SiBr_4$$

(i) Which one is the limiting reagent? Explain your choice.

.....

.....

.....

..... [3]

(ii) How many moles of $SiBr_4$ are formed?

..... [1]

[Total: 8]

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DATA SHEET
The Periodic Table of the Elements

	Group																	
	I	II									III	IV	V	VI	VII	0
																4 He Helium 2
						1 H Hydrogen 1										
	7 Li Lithium 3	9 Be Beryllium 4									11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
	23 Na Sodium 11	24 Mg Magnesium 12									27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
	85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
	Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

*	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
†	232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

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

Key

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

The volume of one mole of any gas is 24 dm^3 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 | | | | | |

CANDIDATE NUMBER | | | | |

0583100121

CHEMISTRY **0620/32**

Paper 3 (Extended) **May/June 2009**

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 16.

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	
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8	
9	
Total	

This document consists of **15** printed pages and **1** blank page.

1 Some grass is crushed and mixed with the solvent, propanone. The colour pigme extracted to give a deep green solution.

(a) (i) Draw a labelled diagram to describe how you could show that there is more than one coloured pigment in the green solution.

[3]

(ii) Given a pure sample of chlorophyll, how could you show that the green solution from the grass contained chlorophyll?

.....

.....

.....

..... [2]

(b) Explain the role of chlorophyll in green plants.

.....

.....

.....

.....

.....

..... [3]

[Total: 8]

2 The results of experiments on electrolysis using inert electrodes are given in the table.

Complete the table; the first line has been completed as an example.

electrolyte	change at negative electrode	change at positive electrode	change to electrolyte
molten lead(II) bromide	lead formed	bromine formed	used up
....	lithium formed	chlorine formed	used up
dilute aqueous sodium chloride	.....	.....	....
aqueous copper(II) sulfate	.....	.....	....
....	hydrogen formed	bromine formed	potassium hydroxide formed

[Total: 8]

3 The following is a list of the electron distributions of atoms of unknown elements.

element	electron distribution
A	2,6
B	2,8,4
C	2,8,8,2
D	2,8,18,8
E	2,8,18,8,1
F	2,8,18,18,7

(a) Choose an element from the list for each of the following descriptions.

(i) It is a noble gas. .....

(ii) It is a soft metal with a low density. .....

(iii) It can form a covalent compound with element **A**. .....

(iv) It has a giant covalent structure similar to diamond. .....

(v) It is a diatomic gas with molecules of the type X_2. ..... [5]

(b) Elements **C** and **A** can form an ionic compound.

(i) Draw a diagram that shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use **o** to represent an electron from an atom of **C**.
Use **x** to represent an electron from an atom of **A**.

[3]

(ii) Predict **two** properties of this compound.

.....

.....

..... [2]

[Total: 10]

4 The reactivity series of metals given below contains both familiar and unfamiliar ele
For most of the unfamiliar elements, which are marked *, their common oxidation states
given.

* barium	Ba
* lanthanum	La (+3)
magnesium	
zinc	
* chromium	Cr (+2), (+3), (+6)
iron	
copper	
* palladium	(+2)

Choose metal(s) from the above list to answer the following questions.

(i) Which **two** metals would not react with dilute hydrochloric acid?

..... [2]

(ii) Which **two** unfamiliar metals (*) would react with cold water?

..... [2]

(iii) What is the oxidation state of barium?

..... [1]

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

..... [1]

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

.....

..... [1]

[Total: 7]

5 Insoluble salts are made by precipitation.

(a) A preparation of the insoluble salt iron fluoride is described below.

To 15 cm^3 of aqueous iron(III) chloride, 45 cm^3 of aqueous sodium fluoride is added. The concentration of both solutions is 1.00 mol / dm^3. The mixture is filtered and the precipitate washed with distilled water. Finally, the precipitate is heated in an oven.

(i) Complete the equation.

$$Fe^{3+} + \text{.....}F^- \longrightarrow \text{.....} \quad [2]$$

(ii) Why is the volume of sodium fluoride solution three times that of the iron(III) chloride solution?

.....

..... [1]

(iii) Why is the mixture washed with distilled water?

.....

..... [1]

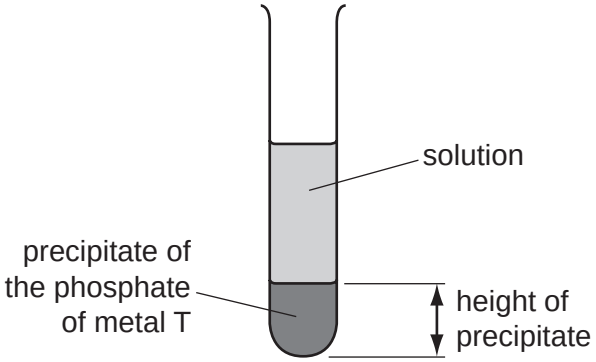
(iv) Why is the solid heated?

.....

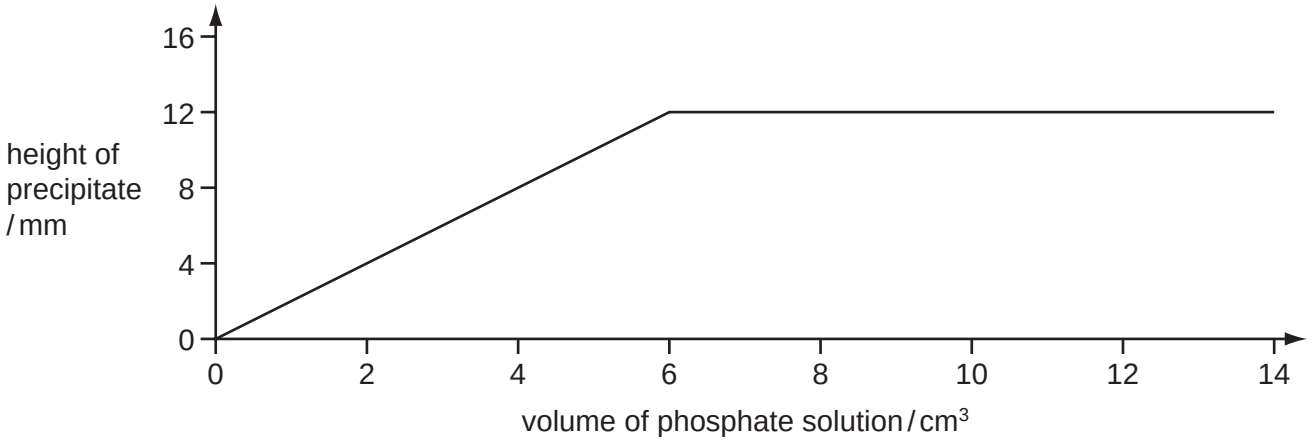
..... [1]

(b) The formulae of insoluble compounds can be found by precipitation reactions.

To 18.0 cm^3 of an aqueous solution of the nitrate of metal T was added 2.0 cm^3 of aqueous sodium phosphate, Na_3PO_4. The concentration of both solutions was 1.00 mol/dm^3. When the precipitate had settled, its height was measured.



The experiment was repeated using different volumes of the phosphate solution. The results are shown on the following graph.



What is the formula of the phosphate of metal T? Give your reasoning.

.....

.....

.....

..... [3]

[Total: 8]

6 Ammonia is manufactured by the Haber process.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ the forward reaction is exothermic

(a) (i) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen from ..... [1]

hydrogen from ..... [1]

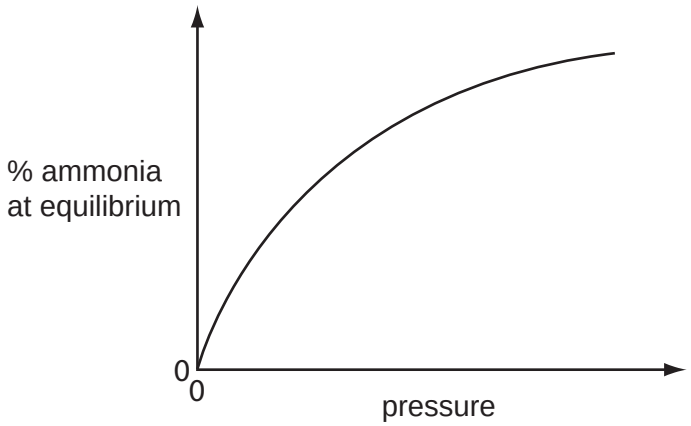
(ii) Name the catalyst used in this process.

..... [1]

(iii) What is the most important use of ammonia?

..... [1]

(b) The following graph shows how the percentage of ammonia in the equilibrium mixture changes with pressure.



(i) Explain the term *equilibrium*.

.....

.....

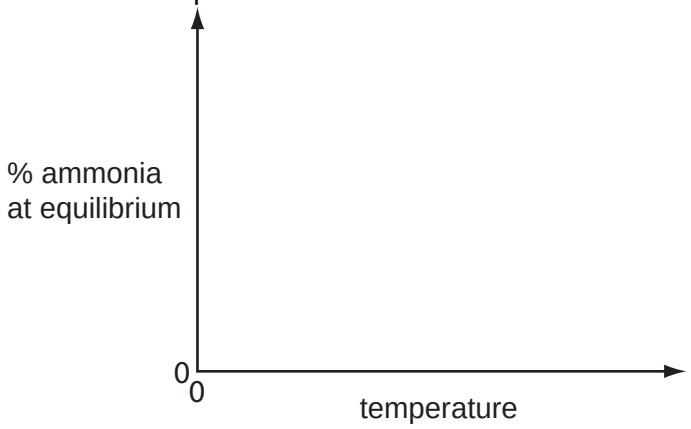
.....

..... [2]

(ii) How does the percentage of ammonia vary with pressure?

..... [1]

(c) **(i)** Sketch a graph which shows how the percentage of ammonia in the equi
mixture varies with temperature.



[1]

(ii) Explain why the graph has the shape shown.

.....

.....

..... [2]

[Total: 10]

7 Hydrogen reacts with the halogens to form hydrogen halides.

(a) Bond energy is the amount of energy, in kJ, that must be supplied (endothermic) t
break one mole of a bond.

bond	bond energy in kJ / mol
H–H	+436
F–F	+158
H–F	+562

Use the above data to show that the following reaction is exothermic.

$$H–H + F–F \rightarrow 2H–F$$

.....

.....

.....

.....

..... [3]

(b) They react with water to form acidic solutions.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$HF + H_2O \rightleftharpoons H_3O^+ + F^-$$

(i) Explain why water behaves as a base in both of these reactions.

.....

..... [2]

(ii) At equilibrium, only 1% of the hydrogen chloride exists as molecules, the rest has formed ions. In the other equilibrium, 97% of the hydrogen fluoride exists as molecules, only 3% has formed ions.

What does this tell you about the strength of each acid?

.....

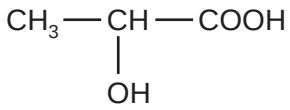
..... [2]

(iii) How would the pH of these two solutions differ?

..... [1]

[Total: 8]

8 Lactic acid can be made from corn starch.



lactic acid

It polymerises to form the polymer, polylactic acid (PLA) which is biodegradable.

(a) Suggest **two** advantages that PLA has compared with a polymer made from petroleum.

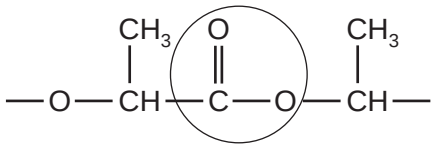
.....

.....

.....

..... [2]

(b) The structure of PLA is given below.



(i) What type of compound contains the group that is circled?

..... [1]

(ii) Complete the following sentence.

Lactic acid molecules can form this group because they contain both an

..... group and an ..... group. [2]

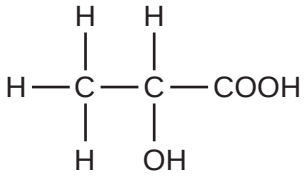
(iii) Is the formation of PLA, an addition or condensation polymerisation? Give a reason for your choice.

.....

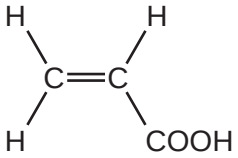
.....

..... [2]

(c) When lactic acid is heated, acrylic acid is formed.



lactic acid



acrylic acid

(i) Complete the word equation for the action of heat on lactic acid.

lactic acid → ..... + ... [1]

(ii) Describe a test that would distinguish between lactic acid and acrylic acid.

test .....

result for lactic acid .....

result for acrylic acid ..... [3]

(iii) Describe a test, other than using an indicator, which would show that both chemicals contain an acid group.

test .....

result .....

..... [2]

[Total: 13]

9 Quantities of chemicals, expressed in moles, can be used to find the formula compound, to establish an equation and to determine reacting masses.

(a) A compound contains 72% magnesium and 28% nitrogen. What is its empirical formula?

.....

.....

.....

..... [2]

(b) A compound contains only aluminium and carbon. 0.03 moles of this compound reacted with excess water to form 0.12 moles of $Al(OH)_3$ and 0.09 moles of CH_4.

Write a balanced equation for this reaction.

.....

.....

.....

..... [2]

(c) 0.08 moles of silicon reacts with 7.2 g of fluorine.

$$Si + 2F_2 \longrightarrow SiF_4$$

(i) Which one is the limiting reagent? Explain your choice.

.....

.....

.....

.....

..... [3]

(ii) How many moles of SiF_4 are formed?

..... [1]

[Total: 8]

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DATA SHEET
The Periodic Table of the Elements

	Group																	
	I	II									III	IV	V	VI	VII	0
																4 He Helium 2
						1 H Hydrogen 1										
	7 Li Lithium 3	9 Be Beryllium 4									11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
	23 Na Sodium 11	24 Mg Magnesium 12									27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
	85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
	Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

*	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
†	232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

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

Key

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

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