



**Cambridge International Examinations**  
Cambridge International General Certificate of Secondary Education

CANDIDATE  
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**CHEMISTRY**

**0620/42**

Paper 4 Theory (Extended)

**February/March 2018**

**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 an HB pencil for any diagrams or graphs.

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

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

You may lose marks if you do not show your working or if you do not use appropriate units.

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 question.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **13** printed pages and **3** blank pages.

\* 2 1 9 9 1 4 0 5 5 1 \*

1 This question is about gases.

(a) The following substances are gases at room temperature.

letter	A	B	C	D	E	F	G	H
substance	SO <sub>2</sub>	Ar	CO	Cl <sub>2</sub>	NH <sub>3</sub>	CO <sub>2</sub>	CH <sub>4</sub>	C <sub>3</sub> H <sub>8</sub>

Identify, by letter:

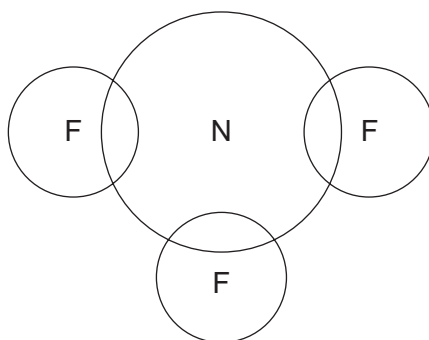
- (i) a gas which combines with water to form acid rain ..... [1]
- (ii) **two** gases which exist as diatomic molecules ..... [2]
- (iii) a gas which bleaches damp litmus paper ..... [1]
- (iv) a gas which is used as an inert atmosphere in lamps ..... [1]
- (v) **two** gases which are found in clean dry air ..... [2]
- (vi) **two** gases which are found in refinery gas. .... [2]

(b) NF<sub>3</sub> has covalent bonds.

(i) What is a covalent bond?

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

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of NF<sub>3</sub>.  
 Show outer shell electrons only.



[3]

(c) Air is a mixture. Nitrogen and oxygen are the two most common gases in air.

(i) What is meant by the term *mixture*?

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

(ii) State the percentage of oxygen, to the nearest whole number, in clean dry air.

..... [1]

(iii) Describe the steps in the industrial process which enables nitrogen and oxygen to be separated from clean dry air.

Use scientific terms in your answer.

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

(iv) Which physical property of nitrogen and oxygen allows them to be separated?

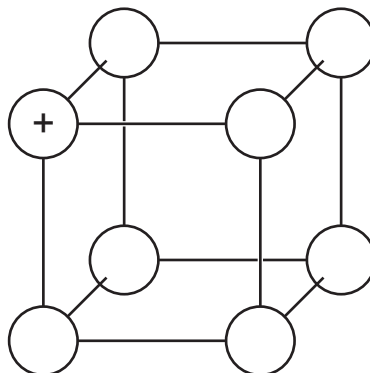
..... [1]

[Total: 20]

2 Sodium chloride is a typical ionic compound.

(a) The diagram shows part of a lattice of sodium chloride.

(i) Complete the diagram to show the ions present. Use '+' for  $\text{Na}^+$  ions and '-' for  $\text{Cl}^-$  ions. One ion has been completed for you.



[2]

(ii) How many electrons does a chloride ion have?

..... [1]

(iii) Identify an element which has atoms with the same number of electrons as a sodium ion.

..... [1]

(b) Electrolysis of concentrated aqueous sodium chloride is an important industrial process.

(i) What is meant by the term *electrolysis*?

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

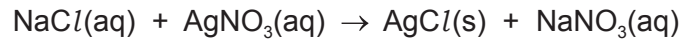
(ii) Name the products of the electrolysis of concentrated aqueous sodium chloride.

1 .....  
 2 .....  
 3 ..... [3]

(iii) Write an ionic half-equation for the reaction at the cathode. Include state symbols.

..... [2]

- (c) Silver chloride can be made by reacting aqueous sodium chloride with aqueous silver nitrate. The other product of the reaction is sodium nitrate. The chemical equation for the reaction is shown.



A student attempted to make the maximum amount of **sodium nitrate** crystals. The process involved three steps.

**step 1** The student added aqueous sodium chloride to aqueous silver nitrate and stirred. Neither reagent was in excess.

**step 2** The student filtered the mixture. The student then washed the residue and added the washings to the filtrate.

**step 3** The student obtained sodium nitrate crystals from the filtrate.

- (i) Describe what the student observed in **step 1**.

..... [1]

- (ii) Why was the residue washed in **step 2**?

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

- (iii) Give the names of the **two** processes which occurred in **step 3**.

1 .....

2 ..... [2]

- (iv) The student started with 20 cm<sup>3</sup> of 0.20 mol/dm<sup>3</sup> NaCl(aq).

- Determine the amount of NaCl(aq) used.

amount of NaCl(aq) used = ..... mol

The yield of NaNO<sub>3</sub> crystals was 90%.

- Calculate the mass of NaNO<sub>3</sub> crystals made.

mass of NaNO<sub>3</sub> crystals = ..... g  
 [4]

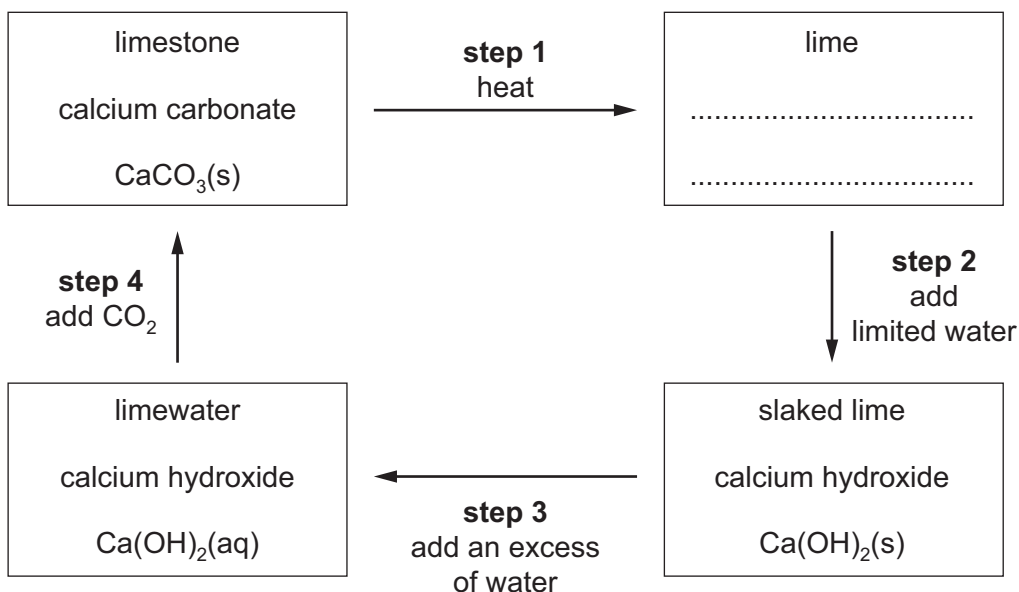
- (v) Write a chemical equation for the action of heat on sodium nitrate crystals.

..... [2]

[Total: 21]

3 Limestone rock is mainly calcium carbonate,  $\text{CaCO}_3$ .

(a) The 'limestone cycle' is shown. Each step is numbered.



(i) Complete the box to give the chemical name and formula of lime. [2]

(ii) Which step involves a physical change?

..... [1]

(iii) What type of reaction is **step 1**?

..... [1]

(iv) Suggest how **step 2** could be reversed.

..... [1]

(v) Write a chemical equation for **step 4**.

..... [1]

(vi) Explain why **step 4** is a neutralisation reaction. Refer to the substances reacting in your answer.

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

(b) Dolomite is a similar rock to limestone. Dolomite contains magnesium carbonate,  $\text{MgCO}_3$ .

Write a chemical equation for the reaction between magnesium carbonate and dilute nitric acid.

..... [2]

(c) Forsterite is another rock which contains a magnesium compound.

A sample of forsterite has the following composition by mass: Mg, 2.73g; Si, 1.58g; O, 3.60g.

Calculate the empirical formula of forsterite.

empirical formula = ..... [2]

[Total: 12]

4 Ammonia is an important chemical.

(a) Ammonia is a base.

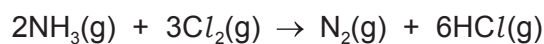
(i) In chemistry, what is meant by the term *base*?

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

(ii) Write a word equation to show ammonia behaving as a base.

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

(b) Ammonia reacts with chlorine. The chemical equation is shown.

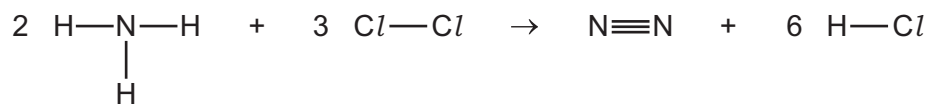


(i) Calculate the volume of chlorine, measured at room temperature and pressure, needed to react completely with 0.68 g of ammonia.

volume of chlorine = ..... cm<sup>3</sup> [3]



(ii) The chemical equation can be represented as shown.



Use the bond energies in the table to determine the energy change,  $\Delta H$ , for the reaction between ammonia and chlorine.

bond	bond energy in kJ/mol
N-H	390
Cl-Cl	240
N≡N	945
H-Cl	430

- energy needed to break bonds

..... kJ

- energy released when bonds are formed

..... kJ

- energy change,  $\Delta H$ , for the reaction between ammonia and chlorine

..... kJ  
[3]

(iii) Is the reaction endothermic or exothermic? Explain your answer.

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

- (c) Ammonia reacts with oxygen at high temperatures in the presence of a suitable catalyst to form nitric oxide, NO.



- (i) Explain how this chemical equation shows ammonia acting as a reducing agent.

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

- (ii) Suggest a suitable catalyst for the reaction from the list of metals. Give a reason for your answer.

**aluminium      calcium      platinum      potassium      sodium**

suitable catalyst .....

reason .....

[2]

[Total: 13]

5 Alcohols are a 'family' of organic molecules which have the same general formula.

(a) What is the name given to any 'family' of organic molecules which have the same general formula and similar chemical properties?

..... [1]

(b) Give the general formula of alcohols.

..... [1]

(c) Propan-1-ol can be made from propene.

(i) Name the reagent and give the conditions needed to convert propene into propan-1-ol.

reagent .....

conditions .....

[2]

(ii) Write a chemical equation for the complete combustion of propan-1-ol.

..... [2]

(d) A simple sugar can be represented as shown.



Simple sugars can be polymerised to make more complex carbohydrates.

(i) Complete the diagram to show part of a carbohydrate **polymer** made from the simple sugar shown.



[2]

(ii) Name the chemical process which occurs when a carbohydrate polymer is broken down into simple sugars.

..... [1]

(iii) What conditions are needed for this process to occur?

..... [1]

- (e) Chromatography can be used to identify simple sugars in a mixture.

A student analysed a mixture of simple sugars by chromatography. All the simple sugars in the mixture were colourless.

- (i) What is the name given to the type of substance used to identify the positions of the simple sugars on the chromatogram?

..... [1]

- (ii) The student calculated the  $R_f$  value of a spot on the chromatogram.

Complete the expression for the  $R_f$  value of the spot.

$R_f =$

[1]

- (iii) How could a student identify a simple sugar from its  $R_f$  value?

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

- (iv) Sometimes not all the substances in a mixture can be identified from the chromatogram produced.

Explain why this may happen.

..... [1]

[Total: 14]

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The Periodic Table of Elements

		Group							
I	II	III	IV	V	VI	VII	VIII		
1	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
<b>Key</b>									
atomic number									
atomic symbol									
name									
relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
11	12	13	14	15	16	17	18		
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40		
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57-71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89-103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Cn copernicium —	Nh nihonium —	Dl dubnium —	Fl flerovium —
113	114	115	116	117	118	119	120	121	122
In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	Po polonium —	At astatine —	Rn radon —	Fr francium —
151	152	153	154	155	156	157	158	159	160
Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201
71	72	73	74	75	76	77	78	79	80
Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201
103	104	105	106	107	108	109	110	111	112
No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Cn copernicium —
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Cn copernicium —
169	170	171	172	173	174	175	176	177	178
Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
69	70	71	72	73	74	75	76	77	78
Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Cn copernicium —
165	166	167	168	169	170	171	172	173	174
Ho holmium 165	Dy dysprosium 163	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186
67	68	69	70	71	72	73	74	75	76
Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190
99	100	101	102	103	104	105	106	107	108
Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —
98	99	100	101	102	103	104	105	106	107
Cf californium —	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
66	67	68	69	70	71	72	73	74	75
Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186
98	99	100	101	102	103	104	105	106	107
Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —
65	66	67	68	69	70	71	72	73	74
Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181	W tungsten 184
97	98	99	100	101	102	103	104	105	106
Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —
64	65	66	67	68	69	70	71	72	73
Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178	Ta tantalum 181
96	97	98	99	100	101	102	103	104	105
Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —
63	64	65	66	67	68	69	70	71	72
Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Hf hafnium 178
95	96	97	98	99	100	101	102	103	104
Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —
62	63	64	65	66	67	68	69	70	71
Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
94	95	96	97	98	99	100	101	102	103
Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —
59	60	61	62	63	64	65	66	67	68
Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167
91	92	93	94	95	96	97	98	99	100
Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —
58	59	60	61	62	63	64	65	66	67
Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165
90	91	92	93	94	95	96	97	98	99
Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —
57	58	59	60	61	62	63	64	65	66
La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163
89	90	91	92	93	94	95	96	97	98
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —

lanthanoids

actinoids

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