



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
International General Certificate of Secondary Education

CANDIDATE  
NAME

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**CHEMISTRY**

**0620/31**

Paper 3 (Extended)

**May/June 2013**

**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.

Electronic calculators may be used.

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

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.

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



1 Petroleum contains hydrocarbons which are separated by fractional distillation.

(a) (i) Complete the following definition of a hydrocarbon.

A hydrocarbon is a compound which .....  
 ..... [2]

(ii) Explain what is meant by the term *fractional distillation*.

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

(b) Some of the fractions obtained from petroleum are given below.  
 State a use for each fraction.

bitumen .....  
 lubricating fraction .....  
 paraffin fraction .....  
 gasoline fraction ..... [4]

[Total: 8]

2 An element, **M**, has the electron distribution 2 + 8 + 18 + 3.

(a) Which group in the Periodic Table is element **M** likely to be in?

..... [1]

(b) Predict whether element **M** is a poor or a good conductor of electricity.  
 Give a reason for your answer.

..... [1]

(c) Binary compounds contain two atoms per molecule, for example HCl.  
 Identify an element which could form a binary compound with element **M**.

..... [1]

(d) Predict the formula of the sulfate of **M**. The formula of the sulfate ion is  $\text{SO}_4^{2-}$ .

..... [1]

- (e) The hydroxide of **M** is a white powder which is insoluble in water. Describe how you could show that this hydroxide is amphoteric.

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

[Total: 6]

- 3 A small piece of marble,  $\text{CaCO}_3$ , was added to  $5.0 \text{ cm}^3$  of hydrochloric acid, concentration  $1.0 \text{ mol/dm}^3$ , at  $25^\circ\text{C}$ . The time taken for the reaction to stop was measured. The experiment was repeated using  $5.0 \text{ cm}^3$  of different solutions of acids. The acid was in excess in all of the experiments.

Typical results are given in the table.

experiment	temperature/ $^\circ\text{C}$	acid solution	time/min
1	25	hydrochloric acid $1.0 \text{ mol/dm}^3$	3
2	25	hydrochloric acid $0.5 \text{ mol/dm}^3$	7
3	25	ethanoic acid $1.0 \text{ mol/dm}^3$	10
4	15	hydrochloric acid $1.0 \text{ mol/dm}^3$	8

- (a) (i) Explain why it is important that the pieces of marble are the same size and the same shape.

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

- (ii) How would you know when the reaction had stopped?

..... [1]

- (b) The equation for the reaction in experiment 1 is:



Complete the following ionic equation.



[1]

- (c) (i) Explain why the reaction in experiment 1 is faster than the reaction in experiment 2.

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

- (ii) The acids used for experiment 1 and experiment 3 have the same concentration. Explain why experiment 3 is slower than experiment 1.

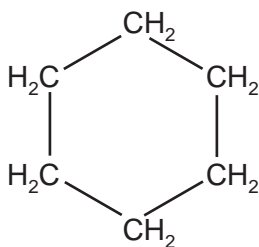
.....  
 .....  
 ..... [2]

- (iii) Explain in terms of collisions between reacting particles why experiment 4 is slower than experiment 1.

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

[Total: 10]

- 4 The structural formula of cyclohexane is drawn below.



- (a) The name gives information about the structure of the compound. **Hex** because there are six carbon atoms and **cyclo** because they are joined in a ring. What information about the structure of this compound is given by the ending **ane**?

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

- (b) What are the molecular and empirical formulae of cyclohexane?

molecular formula .....

empirical formula .....

[2]

(c) Draw the structural formula of cyclobutane.

[1]

(d) (i) Deduce the molecular formula of hexene.

..... [1]

(ii) Explain why cyclohexane and the alkene, hexene, are isomers.

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

(e) Describe a test which would distinguish between cyclohexane and the unsaturated hydrocarbon hexene.

test .....

result of test with cyclohexane .....

.....

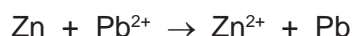
result of test with hexene .....

..... [3]

[Total: 11]

5 The reactivity series shows the metals in order of reactivity.

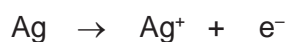
- (a) The reactivity series can be established using displacement reactions. A piece of zinc is added to aqueous lead nitrate. The zinc becomes coated with a black deposit of lead.



Zinc is more reactive than lead.

The reactivity series can be written as a list of ionic equations.

.....  $\rightarrow$  ..... + ..... most reactive metal: the best reductant (reducing agent)



- (i) In the space at the top of the list, write an ionic equation for a metal which is more reactive than zinc. [1]

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

..... [2]

- (iii) Explain why the positive ions are likely to be oxidants (oxidising agents).

..... [1]

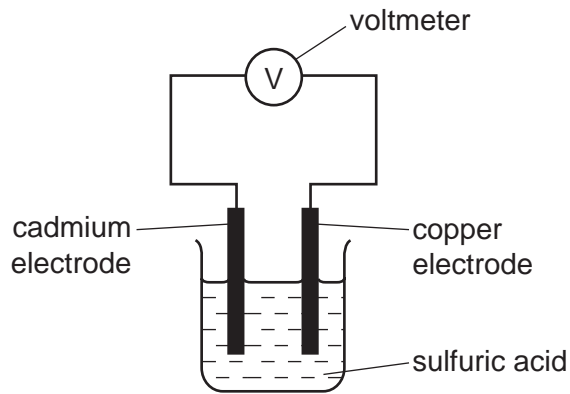
- (iv) Deduce which ion is the best oxidant (oxidising agent).

..... [1]

- (v) Which ion(s) in the list can oxidise lead metal?

..... [1]

- (b) A reactivity series can also be established by measuring the voltage of simple cells. The diagram shows a simple cell.



Results from cells using the metals tin, cadmium, zinc and copper are given in the table below.

cell	electrode 1 positive electrode	electrode 2 negative electrode	voltage /volts
1	copper	cadmium	0.74
2	copper	tin	0.48
3	copper	zinc	1.10

Write the four metals in order of increasing reactivity and explain how you used the data in the table to determine this order.

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

[Total: 9]

- 6 Ammonia is a compound which only contains the elements nitrogen and hydrogen. It is a weak base.

- (a) (i) Define the term *base*.

..... [1]

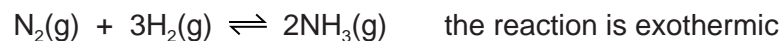
- (ii) Given aqueous solutions of ammonia and sodium hydroxide, both having a concentration of  $0.1 \text{ mol/dm}^3$ , how could you show that ammonia is the weaker base?

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

- (b)** Ammonia is manufactured by the Haber Process. The economics of this process require that as much ammonia as possible is made as quickly as possible. Explain how this can be done using the following information.

The conditions for the following reversible reaction are:

- 450 °C
- 200 atmospheres pressure
- iron catalyst



.....

.....

.....

.....

.....

.....

.....

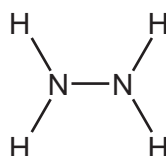
..... [5]

- (c)** Another compound which contains only nitrogen and hydrogen is hydrazine,  $\text{N}_2\text{H}_4$ .

Complete the equation for the preparation of hydrazine from ammonia.



- (d)** The structural formula of hydrazine is given below.



Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound hydrazine.

Use x to represent an electron from a nitrogen atom.

Use o to represent an electron from a hydrogen atom.

[3]



(e) Hydrazine is a weak base and it removes dissolved oxygen from water. It is added to water in steel boilers to prevent rusting.

(i) One way it reduces the rate of rusting is by changing the pH of water. What effect would hydrazine have on the pH of water?

..... [1]

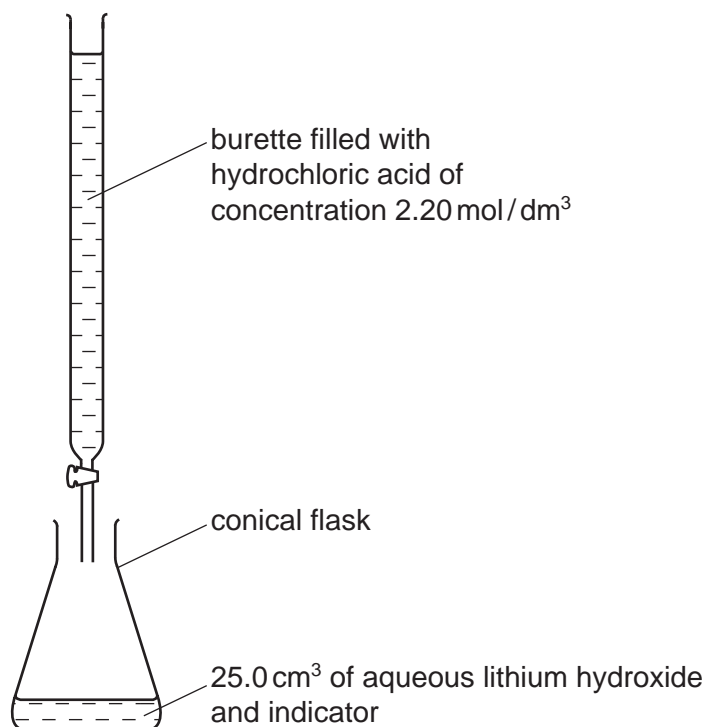
(ii) Give a reason, other than pH, why hydrazine reduces the rate of rusting.

..... [1]

[Total: 15]

7 The hydroxides of the Group I metals are soluble in water. Most other metal hydroxides are insoluble in water.

(a) (i) Crystals of lithium chloride can be prepared from lithium hydroxide by titration.



25.0 cm<sup>3</sup> of aqueous lithium hydroxide is pipetted into the conical flask. A few drops of an indicator are added. Dilute hydrochloric acid is added slowly to the alkali until the indicator just changes colour. The volume of acid needed to neutralise the lithium hydroxide is noted.

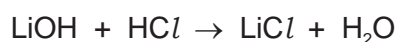
A neutral solution of lithium chloride, which still contains the indicator, is left. Describe how you could obtain a neutral solution of lithium chloride which does **not** contain an indicator.

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

- (ii) You cannot prepare a neutral solution of magnesium chloride by the same method. Describe how you could prepare a neutral solution of magnesium chloride.

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

- (b) The concentration of the hydrochloric acid was  $2.20 \text{ mol/dm}^3$ . The volume of acid needed to neutralise the  $25.0 \text{ cm}^3$  of lithium hydroxide was  $20.0 \text{ cm}^3$ . Calculate the concentration of the aqueous lithium hydroxide.



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

- (c) Lithium chloride forms three hydrates. They are  $\text{LiCl}\cdot\text{H}_2\text{O}$ ,  $\text{LiCl}\cdot 2\text{H}_2\text{O}$  and  $\text{LiCl}\cdot 3\text{H}_2\text{O}$ . Which **one** of these three hydrates contains 45.9% of water? Show how you arrived at your answer.

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

[Total: 10]

- 8 There are three types of giant structure - ionic, metallic and giant covalent.

- (a) In an ionic compound, the ions are held in a lattice by strong forces.

- (i) Explain the term *lattice*.

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

- (ii) Explain how the ions are held together by strong forces.

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

(b) Describe the bonding in a typical metal.

.....

.....

..... [3]

(c) The electrical conductivities of the three types of giant structure are given in the following table.

type of structure	conductivity of solid	conductivity of liquid
ionic	poor	good
metallic	good	good
giant covalent	poor	poor

Explain the differences in electrical conductivity between the three types of giant structure and the difference, if any, between the solid and liquid states of the same structure.

.....

.....

.....

.....

..... [5]

[Total: 11]

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

		Group																																																																																																																													
I	II	III	IV	V	VI	VII	0																																																																																																																								
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4	1 <b>H</b> Hydrogen 1	11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	13 <b>Al</b> Aluminium 13	14 <b>N</b> Nitrogen 7	15 <b>O</b> Oxygen 8	16 <b>F</b> Fluorine 9	17 <b>Ne</b> Neon 10	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	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	133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56	139 <b>La</b> Lanthanum 57	178 <b>Hf</b> Hafnium 72	181 <b>Ta</b> Tantalum 73	184 <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	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	212 <b>Po</b> Polonium 84	214 <b>At</b> Astatine 85	216 <b>Rn</b> Radon 86	226 <b>Ra</b> Radium 88	227 <b>Ac</b> Actinium 89	232 <b>Th</b> Thorium 90	238 <b>U</b> Uranium 92	238 <b>Np</b> Neptunium 93	238 <b>Pu</b> Plutonium 94	238 <b>Am</b> Americium 95	238 <b>Cm</b> Curium 96	238 <b>Bk</b> Berkelium 97	238 <b>Cf</b> Californium 98	238 <b>Es</b> Einsteinium 99	238 <b>Fm</b> Fermium 100	238 <b>Md</b> Mendelevium 101	238 <b>No</b> Nobelium 102	238 <b>Lr</b> Lawrencium 103	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	159 <b>Tb</b> Terbium 65	162 <b>Dy</b> Dysprosium 66	165 <b>Ho</b> Holmium 67	167 <b>Er</b> Erbium 68	169 <b>Tm</b> Thulium 69	173 <b>Yb</b> Ytterbium 70	175 <b>Lu</b> Lutetium 71

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

Key

a	<b>X</b>
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.).

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