



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

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**CHEMISTRY**

**0620/42**

Paper 4 Theory (Extended)

**February/March 2019**

**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.

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

This document consists of **14** printed pages and **2** blank pages.

1 Period 3 of the Periodic Table is shown.

sodium	magnesium	aluminium	silicon	phosphorus	sulfur	chlorine	argon
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Answer the following questions using only these elements.  
Each element may be used once, more than once or not at all.

State which element:

(a) is a gas at room temperature and pressure

..... [1]

(b) forms a basic oxide with a formula of the form  $X_2O$

..... [1]

(c) is made of atoms which have a full outer shell of electrons

..... [1]

(d) forms an oxide which causes acid rain

..... [1]

(e) is extracted from bauxite

..... [1]

(f) forms an oxide which has a macromolecular structure

..... [1]

(g) consists of diatomic molecules.

..... [1]

[Total: 7]

- 2 (a) The table gives information about some atoms or ions, **A**, **B** and **C**.

Complete the table.

	number of protons	number of electrons	electronic structure	charge
<b>A</b>	11	10	2,8	
<b>B</b>		18		0
<b>C</b>		10	2,8	-1

[4]

- (b) (i) Carbon is an element.

Define the term *element*.

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

- (ii)  $^{12}_6\text{C}$ ,  $^{13}_6\text{C}$  and  $^{14}_6\text{C}$  are isotopes of carbon.

Complete the table.

	number of protons	number of neutrons
$^{12}_6\text{C}$		
$^{13}_6\text{C}$		
$^{14}_6\text{C}$		

[2]

[Total: 7]

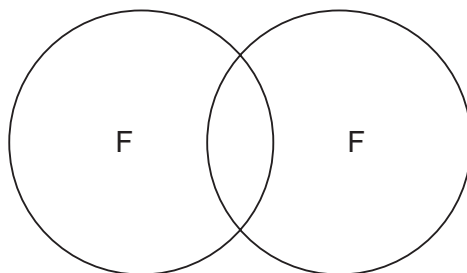
3 Fluorine is a Group VII element. Fluorine forms compounds with metals and non-metals.

(a) Predict the physical state of fluorine at room temperature and pressure.

..... [1]

(b) Fluorine exists as diatomic molecules.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of fluorine. Show outer shell electrons only.



[2]

(c) Write a chemical equation for the reaction between sodium and fluorine.

..... [2]

(d) Explain why chlorine does **not** react with aqueous sodium fluoride.

.....

..... [1]

- (e) Tetrafluoromethane and lead(II) fluoride are fluorides of Group IV elements. Some properties of tetrafluoromethane and lead(II) fluoride are shown in the table.

property	tetrafluoromethane	lead(II) fluoride
formula	CF <sub>4</sub>	
melting point/°C	-184	855
boiling point/°C	-127	1290
conduction of electricity when solid	non-conductor	non-conductor
conduction of electricity when molten	non-conductor	good conductor

- (i) What is the formula of lead(II) fluoride?

..... [1]

- (ii) What type of bonding is present between the atoms in tetrafluoromethane?

..... [1]

- (iii) What type of structure does solid lead(II) fluoride have?

..... [1]

- (iv) Explain, in terms of attractive forces between particles, why lead(II) fluoride has a much higher melting point than tetrafluoromethane.

In your answer refer to the types of attractive forces between particles and their relative strengths.

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

(f) Tetrafluoroethene is an unsaturated compound with the formula  $C_2F_4$ .  
Tetrafluoroethene is the monomer used to make the polymer poly(tetrafluoroethene).

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

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

(ii) Describe a test to show that tetrafluoroethene is unsaturated.

test.....  
observations ..... [2]

(iii) Draw the structure of a molecule of tetrafluoroethene. Show all of the atoms and all of the bonds.

[1]

(iv) Tetrafluoroethene can be polymerised to form poly(tetrafluoroethene).

Draw **one** repeat unit of poly(tetrafluoroethene). Show all of the atoms and all of the bonds.

[2]

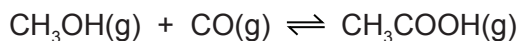
(v) Deduce the empirical formula of:

tetrafluoroethene .....  
poly(tetrafluoroethene). ..... [2]

[Total: 20]

4 This question is about ethanoic acid,  $\text{CH}_3\text{COOH}$ .

(a) Ethanoic acid is manufactured from methanol and carbon monoxide.



The process is done at  $200^\circ\text{C}$  and 30 atmospheres pressure.  
The forward reaction is exothermic.

Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the forward reaction	effect on the equilibrium yield of $\text{CH}_3\text{COOH}(\text{g})$
adding a catalyst		no change
increasing the temperature		
decreasing the pressure	decreases	

[4]

(b) How would you show that an aqueous solution of ethanoic acid is an acid **without** using an indicator or measuring the pH?

State the reagent you would use and give the expected observations. Write a chemical equation for the reaction that you describe.

- reagent

.....

- expected observations

.....

.....

- chemical equation

.....

[3]

(c) Ethanoic acid is a weak acid.

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

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

(ii) Why is ethanoic acid described as *weak*?

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

(d) Ethanoic acid reacts with methanol to form an ester.

(i) State **two** conditions required for this reaction.

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

(ii) Draw the structure of the ester formed when ethanoic acid reacts with methanol. Show all of the atoms and all of the bonds. Name the ester.

structure

name ..... [3]

(iii) Name an ester which is a structural isomer of the ester in (d)(ii).

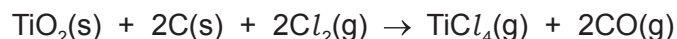
..... [1]

[Total: 15]



5 Titanium is extracted from an ore called rutile. Rutile is an impure form of titanium(IV) oxide,  $\text{TiO}_2$ .

- (a) Rutile is mixed with coke and heated in a furnace through which chlorine gas is passed. The product is gaseous titanium(IV) chloride,  $\text{TiCl}_4$ .



The gaseous titanium(IV) chloride produced is condensed into the liquid state. The titanium(IV) chloride is then separated from liquid impurities.

- (i) Suggest the name of the process by which liquid titanium(IV) chloride could be separated from the liquid impurities.

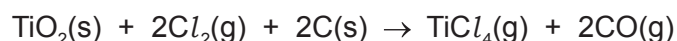
..... [1]

- (ii) Carbon monoxide,  $\text{CO}(\text{g})$ , is also produced in the reaction.

Why should carbon monoxide **not** be released into the atmosphere?

..... [1]

- (b) Calculate the volume of chlorine gas,  $\text{Cl}_2(\text{g})$ , at room temperature and pressure, that reacts completely with 400 g of  $\text{TiO}_2(\text{s})$  using the following steps.



- Calculate the relative formula mass,  $M_r$ , of  $\text{TiO}_2$ .

$M_r$  of  $\text{TiO}_2 = \dots\dots\dots$

- Calculate the number of moles in 400 g of  $\text{TiO}_2$ .

..... mol

- Determine the number of moles of  $\text{Cl}_2$  that react with 400 g of  $\text{TiO}_2$ .

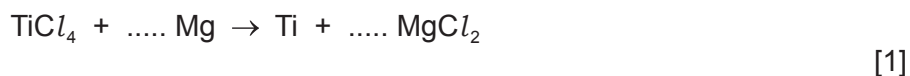
moles of  $\text{Cl}_2 = \dots\dots\dots$  mol

- Calculate the volume of  $\text{Cl}_2$  that reacts with 400 g of  $\text{TiO}_2$ .

volume of  $\text{Cl}_2 = \dots\dots\dots$   $\text{dm}^3$   
[4]

(c) Titanium(IV) chloride,  $TiCl_4$ , is heated with an excess of magnesium, in an atmosphere of argon.

(i) Balance the chemical equation for the reaction.



(ii) Titanium(IV) chloride can be reacted with sodium instead of magnesium.

The reaction between titanium(IV) chloride and sodium is similar to the reaction between titanium(IV) chloride and magnesium.

Write a chemical equation for the reaction between titanium(IV) chloride and sodium.

..... [1]

(iii) Suggest why the reaction between titanium(IV) chloride and magnesium is done in an atmosphere of argon and **not** in air.

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

(d) After titanium(IV) chloride is heated with magnesium, the unreacted magnesium is removed by adding an excess of dilute hydrochloric acid to the mixture.

The dilute hydrochloric acid also dissolves the magnesium chloride.

The dilute hydrochloric acid does **not** react with the titanium or dissolve it.

(i) Give **two** observations and write a chemical equation for the reaction that occurs when dilute hydrochloric acid reacts with magnesium.

1 .....

2 .....

chemical equation ..... [3]

(ii) Name the process that is used to separate the titanium from the mixture after all the magnesium has been removed.

..... [1]

(iii) Titanium does not react with the dilute hydrochloric acid or dissolve in it.

Suggest why titanium does **not** react with dilute hydrochloric acid.

..... [1]

(e) Magnesium cannot be produced by electrolysis of aqueous magnesium chloride using inert electrodes.

(i) Name the product formed at the negative electrode (cathode) during the electrolysis of aqueous magnesium chloride.

..... [1]

(ii) Suggest how magnesium can be produced from magnesium chloride by electrolysis.

..... [1]

[Total: 16]

6 This question is about transition elements.

(a) Transition elements are harder and stronger than Group I elements.

Describe **two** other differences in **physical** properties between transition elements and Group I elements.

1 .....

2 .....

[2]

(b) State **one** physical property of transition elements that is similar to Group I elements.

..... [1]

(c) State **two** chemical properties of transition elements.

1 .....

2 .....

[2]

(d) Cobalt is a transition element. Anhydrous cobalt(II) chloride is used to test for water.

State the colour change that occurs when water is added to anhydrous cobalt(II) chloride.

from ..... to .....

[2]

(e) Iron is a transition element.

(i) Which **two** substances react with iron to form rust?

1 .....

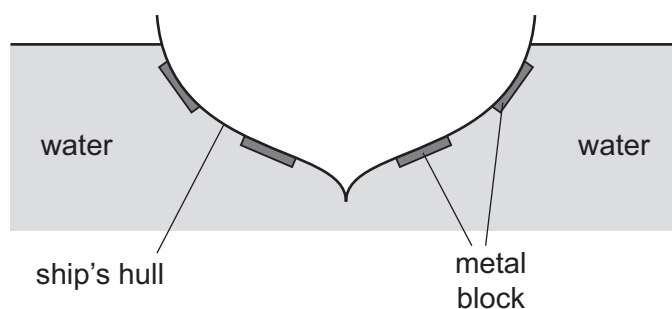
2 .....

[2]

(ii) Which metal is used to galvanise iron?

..... [1]

- (f) The hull of a ship is made from steel (mainly iron). Metal blocks are placed on the ship's hull to prevent rusting.



Use your knowledge of the reactivity series to explain why:

- magnesium is suitable to use as the metal blocks
- copper is **not** suitable to use as the metal blocks.

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

- (g) Rust contains iron(III) oxide.

Phosphoric acid,  $\text{H}_3\text{PO}_4$ , can be used to remove rust from an iron object and prevent further rusting.

- (i) Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

- (ii) Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

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

[Total: 15]



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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	11	12	13	14	15	16	17	18																				
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36										
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	Cs caesium 133	Ba barium 137	La lanthanum 139	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	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium 210	At astatine 210	Rn radon 222		
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	Uu ununoctium —	Uub unubium —	Uuc ununcium —	Uud unundecium —	Uue ununeptium —	Uuq ununquadium —	Uur ununhexium —	Uus ununseptium —	Uu8 ununoctium —	Uu9 ununnonium —	Uu10 unundecium —	Uu11 ununtrium —	Uu12 ununtrium —	Uu13 ununtrium —	Uu14 ununtrium —	Uu15 ununtrium —	Uu16 ununtrium —	Uu17 ununtrium —	Uu18 ununtrium —	Uu19 ununtrium —	Uu20 ununtrium —	Uu21 ununtrium —	Uu22 ununtrium —	

## Key

atomic number  
atomic symbol  
name  
relative atomic mass

1  
H  
hydrogen  
1

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

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