



Cambridge International Examinations
Cambridge International General Certificate of Secondary Education (9–1)

CANDIDATE
NAME

CENTRE
NUMBER

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CHEMISTRY

0971/41

Paper 4 Theory (Extended)

May/June 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 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 Substances can be classified as elements, compounds or mixtures.

(a) What is meant by the term *compound*?

.....

.....

..... [2]

(b) Mixtures can be separated by physical processes.

A sequence of physical processes can be used to separate common salt (sodium chloride) from a mixture containing sand and common salt only.

Give the order and the correct scientific term for the physical processes used to separate the common salt from the mixture.

1

2

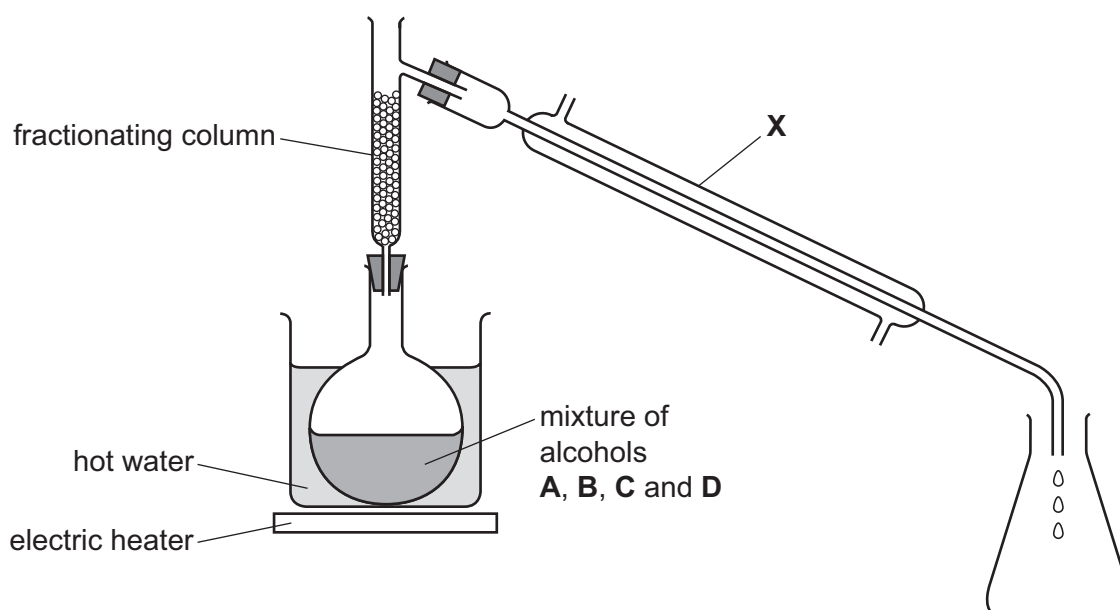
3

[4]

The boiling points of four different alcohols, **A**, **B**, **C** and **D**, are shown.

alcohol	A	B	C	D
boiling point/°C	56	78	122	160

(c) A student suggested that the apparatus shown could be used to separate the mixture of alcohols.



(i) Apparatus **X** needs to have cold water flowing through it.

- Draw an arrow on the diagram to show where the cold water enters apparatus **X**.
- Name apparatus **X**.

..... [2]

(ii) Part of the fractionating column is missing. This means that the experiment will not work.

- Draw on the diagram the part of the fractionating column which is missing.
- Explain why the experiment will **not** work with this part of the fractionating column missing.

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

(iii) Suggest why a Bunsen burner is **not** used to heat the flask.

..... [1]

(iv) A hot water bath cannot be used to separate alcohols **C** and **D**.

Explain why.

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

[Total: 13]

2 Flerovium, Fl, atomic number 114, was first made in research laboratories in 1998.

(a) Flerovium was made by bombarding atoms of plutonium, Pu, atomic number 94, with atoms of element Z.

- The nucleus of **one** atom of plutonium combined with the nucleus of **one** atom of element Z.
- This formed the nucleus of **one** atom of flerovium.

Suggest the identity of element Z.

..... [1]

(b) In which period of the Periodic Table is flerovium?

..... [1]

(c) Predict the number of outer shell electrons in an atom of flerovium.

..... [1]

(d) Two isotopes of flerovium are ^{286}Fl and ^{289}Fl . The nuclei of both of these isotopes are unstable and emit energy when they split up.

(i) State the term used to describe isotopes with unstable nuclei.

..... [1]

(ii) Complete the table to show the number of protons, neutrons and electrons in the atoms of the isotopes shown.

isotope	number of protons	number of neutrons	number of electrons
^{286}Fl			
^{289}Fl			

[2]

(e) Only a relatively small number of atoms of flerovium have been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium is a typical metal.

(i) Suggest **two** physical properties of flerovium.

1

2

[2]

(ii) Suggest **one** chemical property of flerovium oxide.

..... [1]

[Total: 9]

3 This question is about iron.

(a) Three of the raw materials added to a blast furnace used to extract iron from hematite are coke, hematite and limestone.

Name **one** other raw material added to the blast furnace.

..... [1]

(b) A series of reactions occurs in a blast furnace during the extraction of iron from hematite.

Describe these reactions.

Include:

- **one** chemical equation for the reduction of hematite
- **one** chemical equation for the formation of slag.

.....
.....
.....
.....
.....
.....
.....
.....
.....
..... [5]

(c) The iron extracted from hematite using a blast furnace is impure.

Identify the main impurity in this iron and explain how it is removed in the steel-making process.

main impurity

how it is removed

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

[Total: 9]

4 This question is about masses, volumes and moles.

(a) Which term is defined by the following statement?

The average mass of naturally occurring atoms of an element on a scale where the ^{12}C atom has a mass of exactly 12 units.

..... [1]

(b) Butane, C_4H_{10} , has a relative **molecular** mass of 58.
Potassium fluoride, KF, has a relative **formula** mass of 58.

Explain why the term relative molecular mass can be used for butane but **cannot** be used for potassium fluoride.

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

(c) A 0.095 g sample of gaseous element **Y** occupies 60.0 cm^3 at room temperature and pressure.

- Determine the number of moles of element **Y** in 60.0 cm^3 .

moles of element **Y** = mol

- Calculate the relative molecular mass of element **Y** and hence suggest the identity of element **Y**.

relative molecular mass =

identity of element **Y** =

[3]

7

(d) A 1.68g sample of phosphorus was burned and formed 3.87g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = [4]

(e) Another oxide of phosphorus has the empirical formula P_2O_3 .
One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of **one** mole of this oxide of phosphorus.

mass = g [2]

[Total: 12]

- 5 (a) The table gives some chemical properties of transition elements and their compounds, and of Group I elements and their compounds.

chemical property	transition elements	Group I elements
ability to act as catalysts	yes	no
exist as coloured compounds	yes	no

- (i) What is meant by the term *catalyst*?

.....

 [2]

- (ii) Give **one** other chemical property shown by transition elements which is **not** shown by Group I elements.

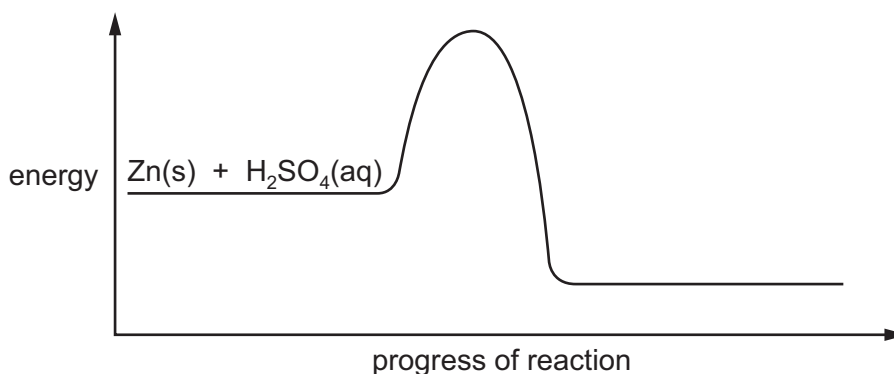
..... [1]

- (b) Give **two** physical properties shown by transition elements which are **not** shown by Group I elements.

1

2 [2]

- (c) The energy level diagram shows the energy profile for the reaction between zinc and dilute sulfuric acid.



- (i) Complete the diagram by adding the formulae of the products. Include state symbols. [3]

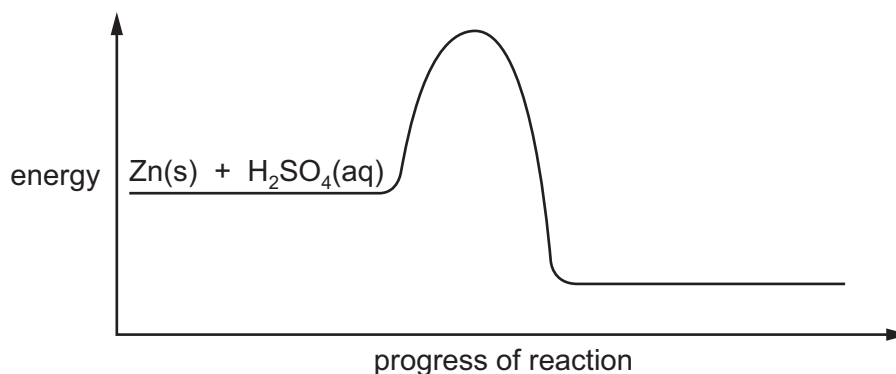
- (ii) Draw an arrow on the diagram to represent the activation energy. [1]

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

.....
 [1]

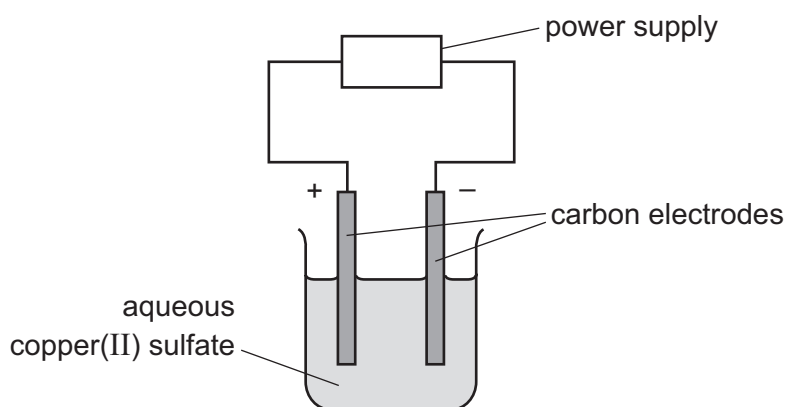
- (d) The reaction between zinc and dilute sulfuric acid can be catalysed by the addition of aqueous copper(II) sulfate.

On the diagram, add the energy profile for the catalysed reaction.



[1]

- (e) A student electrolyses aqueous copper(II) sulfate using the apparatus shown.



Oxygen gas forms at the positive electrode (anode).

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

..... [3]

- (ii) Describe what the student observes at the negative electrode.

..... [1]

- (iii) Give **two other** observations which the student makes during the electrolysis.

1

2 [2]

- (iv) What difference would the student observe at the positive electrode if the aqueous copper(II) sulfate were replaced by concentrated aqueous copper(II) chloride?

..... [1]

[Total: 18]

6 The table shows the structures of four hydrocarbons.

P	Q	R	S
$\text{CH}_3\text{-CH}_3$	$\text{CH}_2=\text{CH}_2$	$\text{CH}_2=\text{CH-CH}_3$	$\text{CH}_2=\text{CH-CH}_2\text{-CH}_3$

(a) Why are compounds **P**, **Q**, **R** and **S** known as hydrocarbons?

.....
 [2]

(b) Compound **P** is saturated.

What is meant by the term *saturated*?

.....
 [1]

(c) Compound **P** undergoes a substitution reaction with chlorine.

(i) What is meant by the term *substitution reaction*?

.....
 [1]

(ii) State a condition required for this reaction to occur.

..... [1]

(iii) Write a chemical equation for this reaction.

..... [2]

(d) Compound **R** undergoes an addition reaction with bromine.

(i) Why is this reaction an addition reaction?

..... [1]

(ii) A compound containing bromine is formed in this reaction.

Draw the structure of this compound. Show all of the atoms and all of the bonds.

[1]

- (e) Draw the structure of an unbranched isomer of compound **S**. Show all of the atoms and all of the bonds. Name this unbranched isomer of compound **S**.

structure

name [2]

- (f) Compound **Q** undergoes polymerisation.

- (i) Name the polymer formed.

..... [1]

- (ii) Complete the chemical equation to show the polymerisation of compound **Q**.



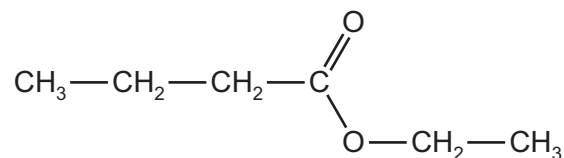
- (g) Amino acids undergo polymerisation to form proteins. Part of a protein molecule with the linkages missing is shown.

Draw the linkages on the diagram. Show all of the atoms and all of the bonds.



[2]

- (h) The structure shows an ester.



Write the word equation for a reaction which could be used to make this ester.

..... [3]

[Total: 19]

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		
Key									
atomic number atomic symbol name relative atomic mass									
3	4	11	12	13	14	15	16	17	18
Li lithium 7	Be beryllium 9	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 —
atomic number atomic symbol name relative atomic mass									
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 —
137	138	139	140	141	142	143	144	145	146
Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Cn copernicium —	Nh nihonium —
151	152	153	154	155	156	157	158	159	160
Uu ununoctium —	Uub unubium —	Uut ununtrium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —
173	174	175	176	177	178	179	180	181	182
Uy ununheptium —	Uub unubium —	Uut ununtrium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —
197	198	199	200	201	202	203	204	205	206
Ug ununogtium —	Uuh ununhectium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —
217	218	219	220	221	222	223	224	225	226
Uq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —
237	238	239	240	241	242	243	244	245	246
Uq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —	Uus ununsextium —	Uuo ununseptium —	Uuq ununquadium —	Uur ununpentium —

lanthanoids

actinoids

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
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	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).