Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTER NUMBER

CANDIDATE NUMBER

CHEMISTRY (US) **0439/21**

Paper 2 **May/June 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Center number, candidate number and name in the spaces at the top of this page.
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 20.
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 **17** printed pages and **3** blank pages.

CAMBRIDGE International Examinations

1 **(a)** Choose from the list of substances below to answer the following questions.

calcium oxide
carbon dioxide
carbon monoxide
copper
hydrogen
magnesium
methane
oxygen
water

Each substance may be used once, more than once or not at all.

Which substance:

(i) releases hydrogen when it reacts with steam,

..... [1]

(ii) is produced at the cathode when concentrated aqueous sodium chloride is electrolyzed,

..... [1]

(iii) is a product of the incomplete combustion of carbon,

..... [1]

(iv) is used in electrical wiring,

..... [1]

(v) is manufactured by heating limestone?

..... [1]

(b) Complete the following sentences about the Periodic Table of elements using words from the list below.

argon	**color**	**density**	**sodium**
one	**similarity**	**trend**	**seven**

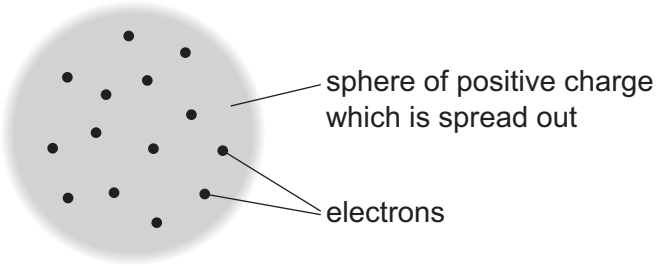
Chlorine, bromine and iodine are elements in Group ..... of the Periodic Table.

These elements show a ..... in ..... down the group.

They all react rapidly with ..... to form ionic compounds. [4]

[Total: 9]

2 In 1904, J. J. Thomson suggested a model of the atom. He called this the 'plum pu[illegible]'.
This model of an atom, containing 14 electrons, is shown below.



(a) Describe how Thomson's model of the atom differs from our present ideas of the structure of an atom.

.....

.....

.....

..... [3]

(b) Lithium has two naturally-occurring isotopes. These can be written as:

$^{6}_{3}Li$ and $^{7}_{3}Li$

(i) Describe the difference between these isotopes.

..... [1]

(ii) Isotopes can be radioactive or nonradioactive.
State **one** industrial use of radioactive isotopes.

..... [1]

(c) Lithium is in Group I of the Periodic Table.
The table shows some properties of the Group I elements.

metal	melting point / °C	atomic radius / nm
lithium		0.157
sodium	98	0.191
potassium	63	
rubidium	39	0.250
caesium	29	0.272

Deduce:

the melting point of lithium, ... °C

the atomic radius of potassium ..... nm [2]

(d) Lithium reacts with water. An alkaline solution and a colorless gas are formed.

(i) Complete the word equation for this reaction.

lithium + water → .... + ...

[2]

(ii) What is the most likely pH of the alkaline solution?
Put a ring around the correct answer.

pH 2 **pH 5** **pH 7** **pH 13**

[1]

(e) Draw the electronic structure of a potassium atom.

[2]

[Total: 12]

3 The table shows some fractions obtained from the distillation of petroleum.

fraction	number of carbon atoms	boiling point of the fraction / °C
refinery gas	1 – 4	under 40
gasoline	5 – 10	40 – 160
kerosene	10 – 16	160 – 250
diesel	16 – 20	250 – 300
fuel oil	20 – 30	300 – 350

(a) What is the relationship between the number of carbon atoms and the boiling points of the fractions?

..... [1]

(b) State the names of **two** petroleum fractions not given in the table.

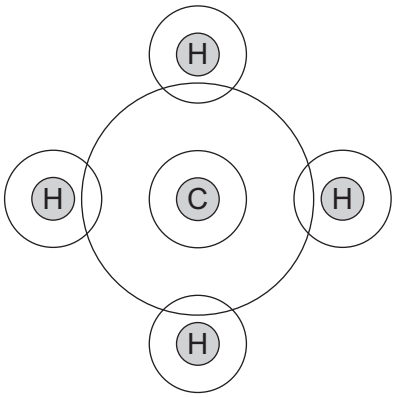
..... and ..... [2]

(c) Two of the compounds present in refinery gas are methane and ethane.

(i) Draw the structure of ethane. Show all atoms and bonds.

[1]

(ii) Complete the dot and cross diagram of methane to show **all** the electrons.



[2]

(d) Refinery gas also contains propane.
Propane can be cracked in the presence of a catalyst to form hydrogen.

(i) Complete the symbol equation for this reaction.

$$C_3H_8 \rightarrow \text{.....} + H_2$$

[1]

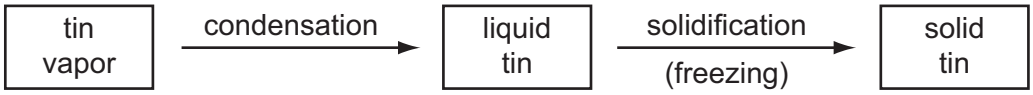
(ii) A catalyst is one condition needed to crack an alkane.

State **one** other condition needed to crack an alkane.

..... [1]

[Total: 8]

4 The diagram shows the changes of state when tin vapor is cooled slowly to room tem



(a) Explain what happens to the arrangement and motion of the atoms during these changes.

.....

.....

.....

.....

..... [4]

(b) Tin is a metal in Group IV of the Periodic Table.
How many electrons does tin have in its outer shell?

..... [1]

(c) State **one** physical property of tin.

..... [1]

(d) The table below describes the reaction of some metals with dilute hydrochloric acid.

iron	bubbles of gas produced and temperature of the mixture rises slowly
magnesium	many bubbles of gas produced rapidly and temperature of the mixture rises rapidly
silver	no bubbles of gas given off and no temperature change
tin	a few bubbles of gas given off slowly and temperature of the mixture rises very slowly

Put these metals in order of their reactivity.

least reactive ⟶ most reactive

[2]

(e) Tin is extracted by heating tin(IV) oxide with carbon.

(i) Complete the symbol equation for this reaction.

$$SnO_2 \quad + \quad .....C \quad \rightarrow \quad Sn \quad + \quad .....CO$$

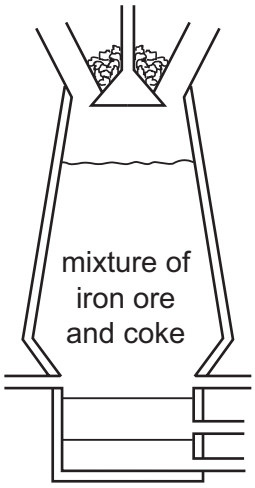
[2]

(ii) State **one** adverse effect of carbon monoxide on health.

..... [1]

[Total: 11]

5 The diagram shows a blast furnace for extracting iron.



(a) On the diagram above, write:

- the letter **A** to show where the air blast enters the furnace,
- the letter **W** to show where the waste gases exit the furnace.

[2]

(b) Which **one** of the following is an ore of iron?
Put a ring around the correct answer.

calcite **fluorite** **hematite** **halite**

[1]

(c) In the furnace, the coke burns to form carbon dioxide. This reaction is exothermic.

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

..... [1]

(ii) Describe a test for carbon dioxide.

test .....

result ..... [2]

(d) In the blast furnace, carbon dioxide reacts with more coke to form carbon monoxide.
The carbon monoxide reduces iron(III) oxide to iron.

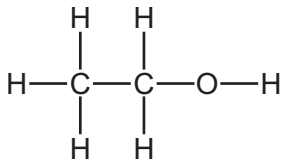
$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

How does this equation show that iron(III) oxide is being reduced?

..... [1]

[Total: 7]

6 The structure of ethanol is shown below.



(a) On the structure above, put a ring around the alcohol functional group. [1]

(b) Ethanol can be made by fermentation.

(i) Complete the word equation for fermentation.

..... → ethanol + ...

[2]

(ii) What type of catalysts are used in fermentation?
Put a ring around the correct answer.

acids **carbonates** **enzymes** **metals**

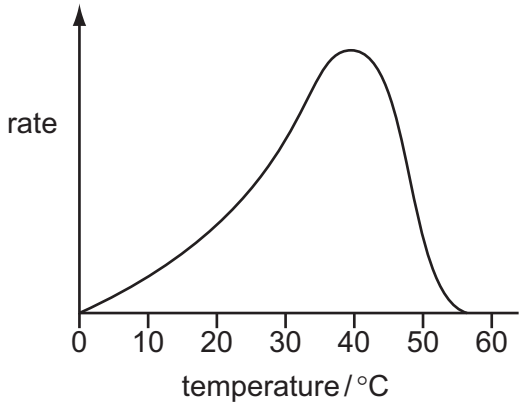
[1]

(c) Ethanol can also be made by hydration.
Complete the symbol equation for this reaction.

..... + H_2O → C_2H_5OH

[1]

(d) The diagram below shows how the rate of fermentation changes with temperature.



Describe how the rate of fermentation changes with temperature.

.....

.....

..... [2]

(e) The table shows some properties of different alcohols.

alcohol	formula	melting point / °C	boiling point / °C	density in g / cm^3
methanol	CH_4O	–94	65	
ethanol	C_2H_6O	–117	79	0.789
propanol	C_3H_8O	–126	98	0.804
butanol	$C_4H_{10}O$	–89	117	0.810
pentanol	$C_5H_{12}O$	–79	138	0.815

(i) Describe how density changes with the number of carbon atoms in the alcohol.

..... [1]

(ii) Which **one** of these alcohols has the lowest melting point?

..... [1]

(iii) Is pentanol a solid, liquid or gas at room temperature?
Explain your answer.

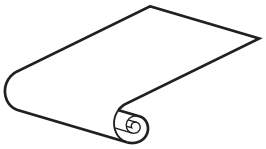
.....

.....

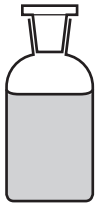
..... [1]

[Total: 10]

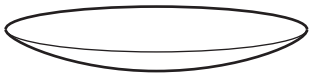
7 A student used chromatography to separate the dyes in the blue ink from an ink pen.
She used the equipment shown in the diagrams below.



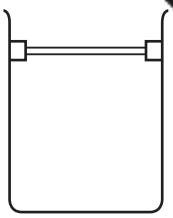
chromatography paper



solvent

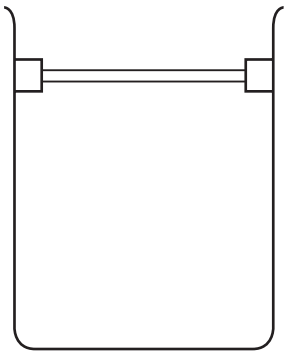


large watchglass



chromatography tank

(a) Complete the diagram below to show how she set up the apparatus.



[3]

(b) Describe how chromatography could be used by the student to separate the dyes.

.....

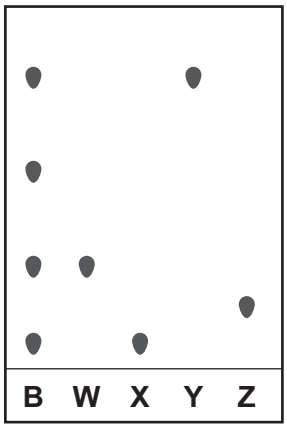
.....

..... [3]

(c) The student used water as a solvent. Suggest a different solvent that she could use.

..... [1]

(d) The diagram below shows the results of the chromatography using the blue ink, **B**, and four pure dyes, **W**, **X**, **Y** and **Z**.



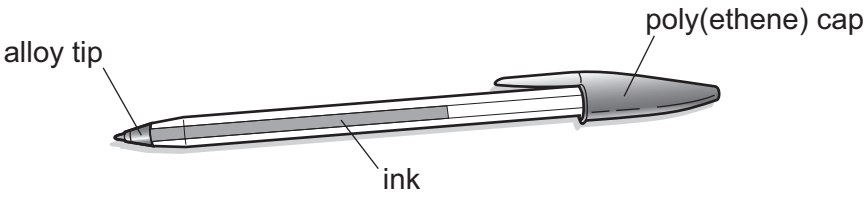
(i) Which of the dyes, **W**, **X**, **Y** and **Z**, were in the blue ink?

..... [1]

(ii) How many dyes in the ink had been separated by this chromatography?

..... [1]

(e) The diagram shows the pen used in the experiment.



(i) The cap of the pen is made of poly(ethene).
Describe the formation of poly(ethene) from ethene. In your answer, include the words:

- monomer,
- polymer.

.....

.....

..... [2]

(ii) The tip of the pen is made from an alloy.
What is meant by the term *alloy*?

.....

..... [1]

(f) The table shows some properties of four alloys.

alloy	strength / GPa	density in g / cm^3	thermal conductivity in W / m / K
low strength steel	250	7.70	60
high strength steel	300	7.90	56
low strength aluminum	70	2.72	170
high strength aluminum	220	2.80	100

(i) How does the strength of the steel and aluminum alloys vary with their thermal conductivity?

..... [1]

(ii) Which **one** of these alloys is the best one to use to make the body of an airplane? Give **two** reasons for your answer.

.....

.....

..... [3]

[Total: 16]

8 Zinc can be extracted from zinc sulfide ore in three steps.

(a) In the first step, zinc sulfide is heated in air to produce zinc oxide.

(i) Complete the symbol equation for this reaction.

$$2ZnS + ...O_2 \rightarrow 2ZnO + ...SO_2$$

[2]

(ii) The product sulfur dioxide, SO_2, is harmful to the environment.
Explain why it is harmful to the environment and state **one** effect it has on buildings.

.....

..... [2]

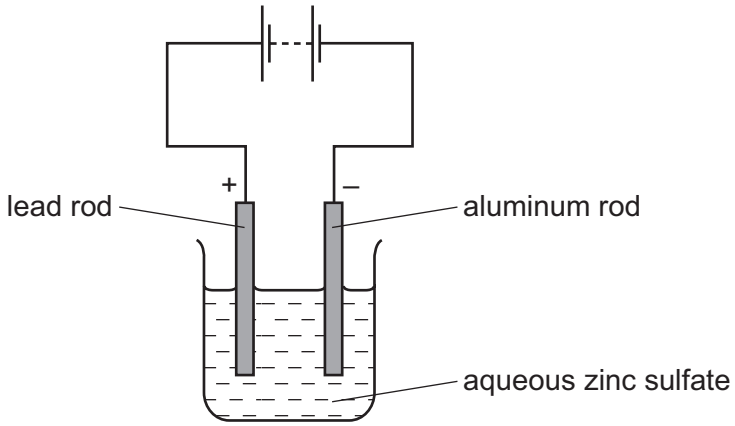
(b) In the second step, zinc oxide reacts with sulfuric acid to form zinc sulfate.

zinc oxide + sulfuric acid → zinc sulfate + water

Zinc sulfate is soluble in water.
Some insoluble impurities in the zinc oxide do not react with the sulfuric acid.
Suggest how these insoluble impurities are removed from the zinc sulfate solution.

..... [1]

(c) In the third step, zinc is extracted from zinc sulfate by electrolysis using the cell shown below.



(i) Which word best describes the aluminum rod?
Put a ring around the correct answer.

anion **anode** **cathode** **cation** **electrolyte** **product**

[1]

(ii) Suggest which statement about this electrolysis is completely correct.
Tick **one** box.

Zinc is formed at the positive electrode and hydrogen at the negative electrode.	☐
Zinc is formed at the positive electrode and oxygen at the negative electrode.	☐
Zinc is formed at the negative electrode and hydrogen at the positive electrode.	☐
Zinc is formed at the negative electrode and oxygen at the positive electrode.	☐

[1]

[Total: 7]

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DATA SHEET
The Periodic Table of the Elements

Group

I	II											III	IV	V	VI	VII	0
							1 **H** Hydrogen 1										4 **He** Helium 2
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.).