



Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

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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.

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

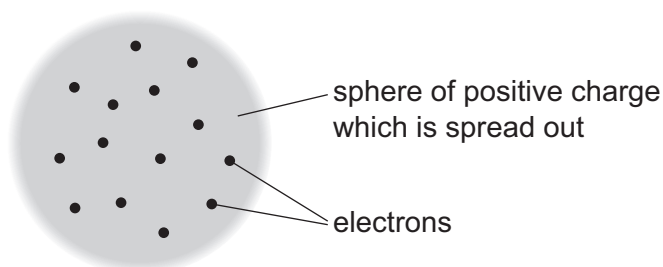
Chlorine, bromine and iodine are elements in Group of the Periodic Table.

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 pudding' model. 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:



- (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.

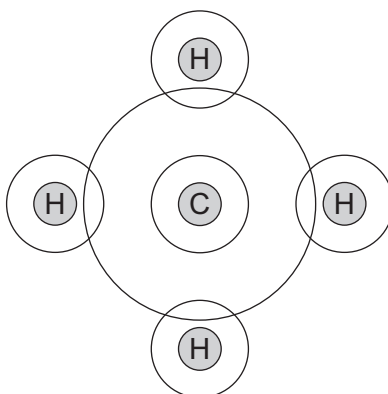
..... and [2]

(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.



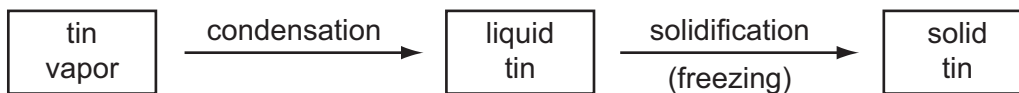
- (ii) A catalyst is one condition needed to crack an alkane.

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 temperature.



- (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

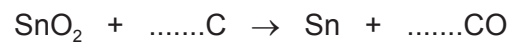
Put these metals in order of their reactivity.

least reactive $\xrightarrow{\hspace{15em}}$ most reactive

[2]

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

(i) Complete the symbol equation for this reaction.



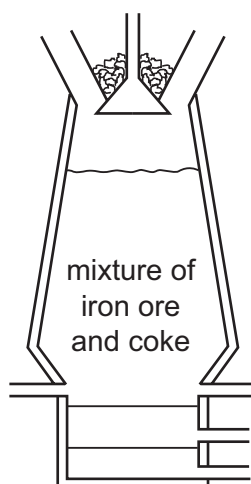
[2]

(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*?

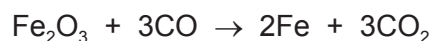
..... [1]

(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.

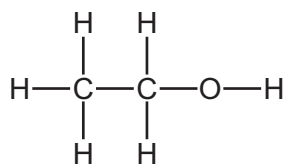


How does this equation show that iron(III) oxide is being reduced?

..... [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

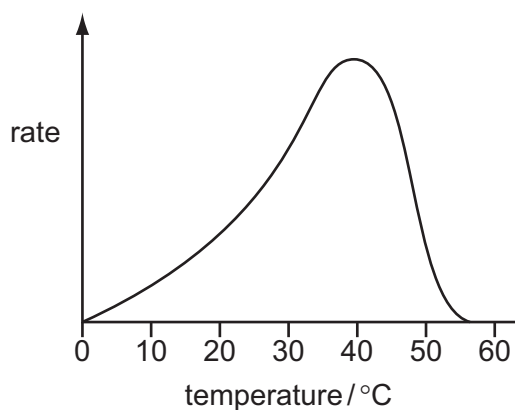
metals

[1]

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

..... + H₂O → C₂H₅OH [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 ₄ O	-94	65	
ethanol	C ₂ H ₆ O	-117	79	0.789
propanol	C ₃ H ₈ O	-126	98	0.804
butanol	C ₄ H ₁₀ O	-89	117	0.810
pentanol	C ₅ H 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]

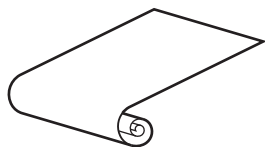
(iii) Is pentanol a solid, liquid or gas at room temperature?
Explain your answer.

.....

 [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.



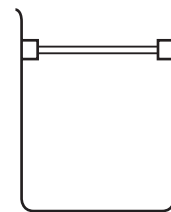
chromatography paper



solvent

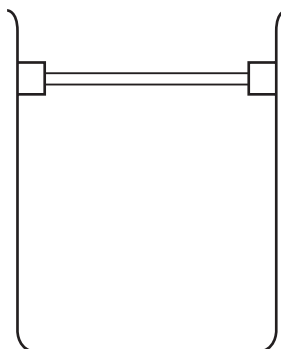


large watchglass



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.

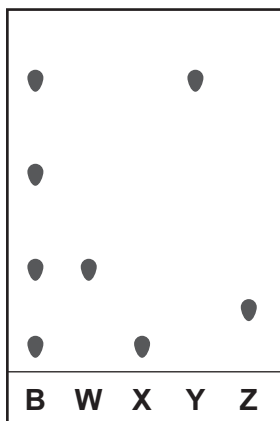
.....

 [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 several pure dyes, **W**, **X**, **Y** and **Z**.



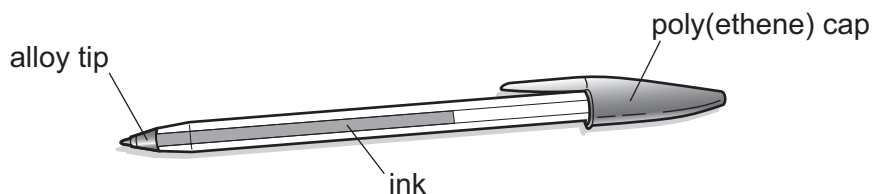
(i) Which of the dyes, **W**, **X**, **Y** and **Z**, were in the blue ink?

..... [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.

.....

.....

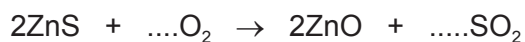
..... [3]

[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.



[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.



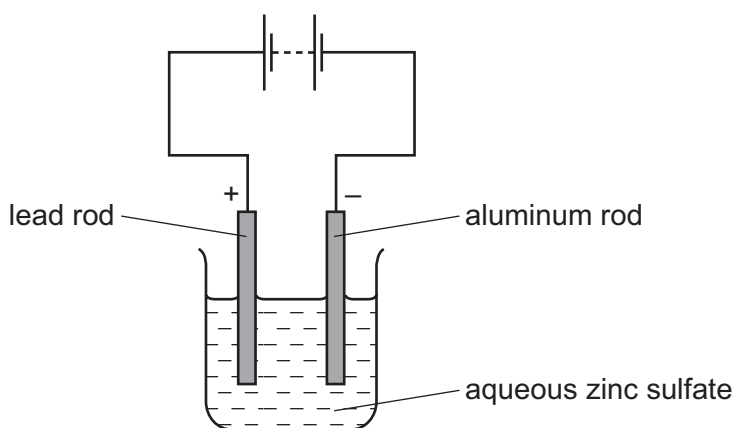
Zinc sulfate is soluble in water.

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]

DATA SHEET
The Periodic Table of the Elements

		Group																		
I	II	III	IV	V	VI	VII	0													
7 Li Lithium 3	9 Be Beryllium 4	1 H Hydrogen 1	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 Aluminum 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	101 Ru Ruthenium 44	101 Rh Rhodium 45	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	208 Po Polonium 84	209 At Astatine 85	210 Rn Radon 86			
87 Fr Francium	226 Ra Radium	227 Ac Actinium																		
				140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	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	238 Pa Protactinium 91	238 U Uranium 92	238 Np Neptunium 93	238 Pu Plutonium 94	238 Am Americium 95	238 Cm Curium 96	238 Bk Berkelium 97	238 Cf Californium 98	238 Es Einsteinium 99	238 Fm Fermium 100	238 Md Mendelevium 101	238 No Nobelium 102	238 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 dm³ at room temperature and pressure (r.t.p.).

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