Cambridge Assessment International Education

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2554114949

CHEMISTRY **0620/32**

Paper 3 Theory (Core) **February/March 2022**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

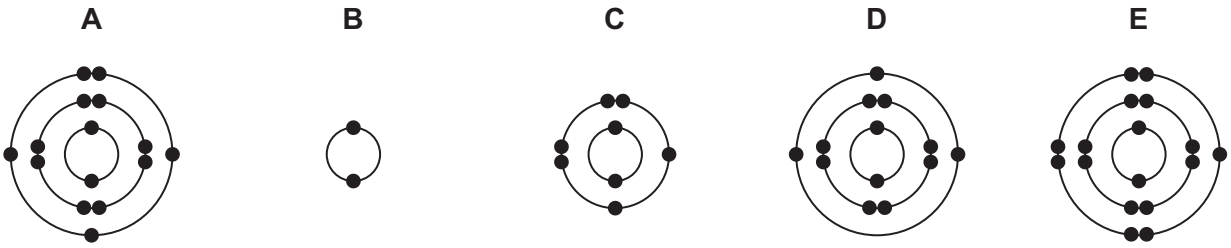
INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

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[Turn over

1 **(a)** The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group V of the Periodic Table

..... [1]

(ii) an atom which contains only two shells of electrons

..... [1]

(iii) an atom that forms a stable ion with a charge of 2–

..... [1]

(iv) an atom of an element that exists as a monoatomic gas

..... [1]

(v) an atom of the metal that is extracted from bauxite.

..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the uranium atom and rubidium ion shown.

	number of electrons	number of neutrons	number of protons
$^{235}_{92}U$	92		
$^{87}_{37}Rb^{+}$		50	

[3]

[Total: 8]

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2 **(a)** Biogas is a mixture of gases produced when agricultural waste is broken down in the absence of oxygen.

The table compares the percentage by mass of the gases present in two samples of biogas, **X** and **Y**.

gas	biogas **X** /% by mass	biogas **Y** /% by mass
carbon dioxide	26	32
hydrogen	1	1
hydrogen sulfide	0.5	0.5
methane	67	56
nitrogen	4	9.5
oxygen	0.5	0.5
other gases		0.5

Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of the other gases in biogas **X**.

..... [1]

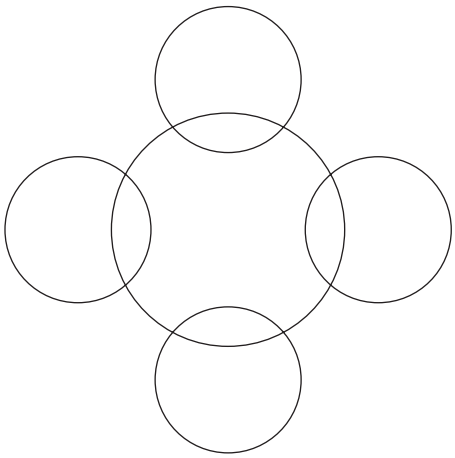
(ii) Describe **two** major differences in the compositions of biogas **X** and biogas **Y**.

1 .....

2 .....

[2]

(b) Complete the diagram to show the electronic structure in a methane molecule.
Show only the outer shell electrons.



[1]

(c) Hydrogen sulfide burns in air to produce sulfur dioxide and water.

(i) Complete the chemical equation for this reaction.

$$.....H_2S + ...O_2 \rightarrow 2H_2O + 2SO_2$$ [2]

(ii) Explain how this equation shows that hydrogen sulfide is oxidised.

.....

..... [1]

[Total: 7]

3 This question is about metals.

(a) State **three** general physical properties common to most metals.

1 .....

2 .....

3 .....

[3]

(b) Metals are often used in the form of alloys.

(i) State the meaning of the term *alloy*.

.....

..... [1]

(ii) Explain in terms of their properties why alloys are used instead of pure metals.

..... [1]

(iii) Stainless steel is an alloy.

Give **one** use of stainless steel.

..... [1]

(c) Place these metals in order of their reactivity with oxygen.

copper
magnesium
potassium
zinc

Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

(d) When 4.8 g of magnesium reacts with excess oxygen, 8.0 g of magnesium oxide is formed.

Calculate the minimum mass of magnesium needed to produce 24.0 g of magnesium oxide.

minimum mass = ... g [1]

[Total: 9]

4 This question is about acids, bases and salts.

(a) Sodium hydroxide is a base.

(i) Name the products formed when sodium hydroxide reacts with dilute nitric acid.

.....

..... [2]

(ii) Describe the effect of sodium hydroxide on a named indicator.

.....

..... [2]

(iii) Complete the word equation for the reaction of sodium hydroxide with ammonium chloride.

sodium hydroxide	+	ammonium chloride	→	.....	+	....	+	water

[2]

(b) Describe how to prepare pure, dry crystals of the salt zinc sulfate from an aqueous solution of zinc sulfate.

.....

.....

..... [2]

(c) The rate of reaction of zinc powder with dilute sulfuric acid is found by measuring the increase in volume of hydrogen gas produced as time increases.

Describe the effect, if any, of each of the following on the rate of this reaction.

- The reaction is carried out with large pieces of zinc instead of zinc powder.

All other conditions stay the same.

.....

- The reaction is carried out using a catalyst.

All other conditions stay the same.

.....

- The reaction is carried out with dilute sulfuric acid of a lower concentration.

All other conditions stay the same.

.....

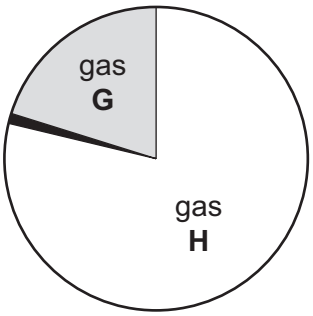
[3]

[Total: 11]

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5 This question is about air.

(a) The pie chart shows the proportions of the main gases in clean, dry air.

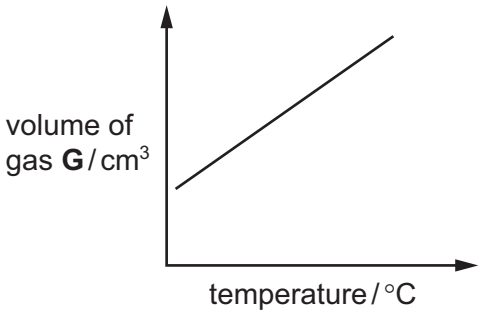


(i) Name the gases **G** and **H**.

gas **G** .....

gas **H** .....
[2]

(ii) The graph shows how the volume of a sample of gas **G** changes as temperature increases. The pressure is kept constant.



Describe how the volume of gas **G** changes as temperature increases.

..... [1]

(iii) There is a small percentage of noble gases in the air.
The noble gases are unreactive.

Explain why the noble gases are unreactive in terms of their electronic structure.

.....

..... [1]

(iv) Describe the arrangement and separation of the particles in a gas.

arrangement .....

separation .....
[2]

(b) Two of the pollutants in air are oxides of nitrogen and lead compounds.

(i) Give **one** effect of each of these pollutants on health.

oxides of nitrogen .....

lead compounds .....
[2]

(ii) Name **two** other pollutants present in air.

State the source of each of these pollutants.

pollutant 1 .....

source of pollutant 1 .....

pollutant 2 .....

source of pollutant 2 .....
[4]

[Total: 12]

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6 The table shows some properties of four Group I elements.

element	melting point / °C	boiling point / °C	relative hardness
lithium	181	1342	.....
sodium	98	.....	0.70
potassium	63	760	0.36
rubidium	39	686	0.22

(a) (i) Complete the table by estimating:
- the boiling point of sodium
- the relative hardness of lithium. [2]

(ii) Predict the physical state of lithium at 200 °C.

Give a reason for your answer.

.....

..... [2]

(b) Potassium reacts with water.

$$2K + 2H_2O \rightarrow 2KOH + H_2$$

Describe **two** observations when potassium reacts with water.

1 .....

2 .....
[2]

(c) Lithium is extracted by the electrolysis of molten lithium chloride.

(i) Name a non-metal used to make the electrodes.

..... [1]

(ii) Give one property, **other** than the conduction of electricity, that makes this substance suitable for use as an electrode.

..... [1]

(iii) State the products of the electrolysis of molten lithium chloride at:

the negative electrode (cathode) .....

the positive electrode (anode). .....
[2]

(d) Lithium chloride conducts electricity when molten and when in aqueous solution.

Give two **other** physical properties of lithium chloride that show it is an ionic compound.

1 .....

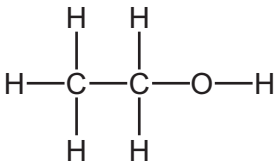
2 .....
[2]

[Total: 12]

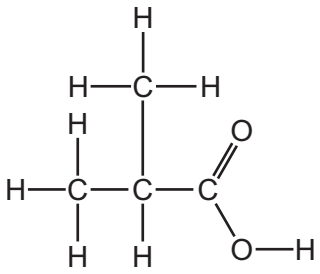
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7 **(a)** The structures of four organic compounds, **P**, **Q**, **R** and **S**, are shown.

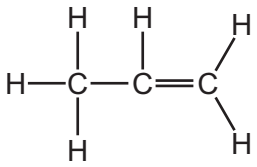
P



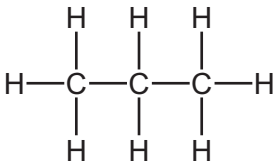
Q



R



S



Answer the following questions about these structures.

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

(i) State which structure, **P**, **Q**, **R** or **S**, has a carboxylic acid functional group.

..... [1]

(ii) State which structure, **P**, **Q**, **R** or **S**, is in the same homologous series as ethane.

..... [1]

(iii) State which structure, **P**, **Q**, **R** or **S**, decolourises aqueous bromine.

..... [1]

(iv) Deduce the molecular formula of structure **Q** to show the number of carbon, hydrogen and oxygen atoms.

..... [1]

(b) Structure **S** is produced by cracking petroleum fractions.

(i) Complete the sentence using a word from the list.

acids **alkenes** **alcohols** **nitrogen**

During cracking, long-chain alkanes are converted to shorter chain alkanes and

..... . [1]

(ii) Cracking is an example of thermal decomposition.

State the meaning of the term *thermal decomposition*.

.....

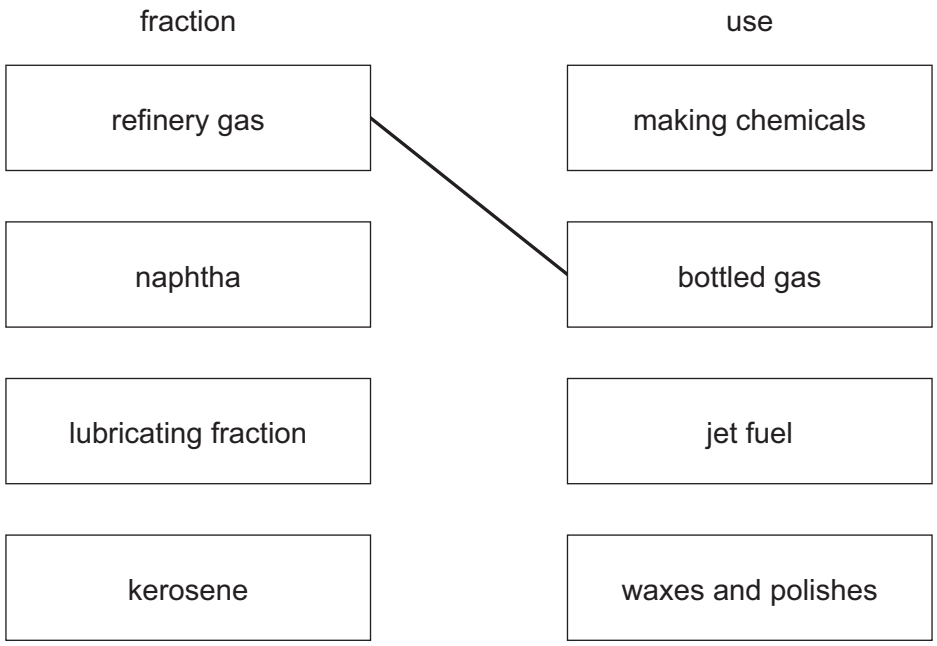
..... [2]

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[Turn over

(c) Link each petroleum fraction on the left to its use on the right.

The first one has been done for you.



[2]

[Total: 9]

8 This question is about chlorine and compounds of chlorine.

(a) Chlorine is an element in Group VII of the Periodic Table.

State the meaning of the term *element*.

.....

..... [1]

(b) State **one** use of chlorine.

..... [1]

(c) Chlorine reacts with phosphorus to produce phosphorus(V) chloride.

(i) Balance the equation for this reaction.

$$.....P + ...Cl_2 \rightarrow 2PCl_5$$ [2]

(ii) This reaction is exothermic.

State the meaning of the term *exothermic*.

..... [1]

(d) Chlorine reacts with aqueous sodium bromide.

(i) Complete the word equation for this reaction.

chlorine	+	sodium bromide	→	.....	+	....

[2]

(ii) Describe a test for bromide ions.

test .....

observations .....

[2]

(iii) When bromine is mixed with aqueous sodium chloride there is no reaction.

Suggest in terms of chemical reactivity why there is no reaction.

..... [1]

(e) A compound of chlorine has the formula $C_3H_6Cl_2$.

Complete the table to calculate the relative molecular mass of $C_3H_6Cl_2$.

atom	number of atoms	relative atomic mass	
carbon	3	12	$3 \times 12 = 36$
hydrogen		1	
chlorine		35.5	

relative molecular mass = ... [2]

[Total: 12]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

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^3 at room temperature and pressure (r.t.p.).