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CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

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CHEMISTRY **0620/31**

Paper 3 Theory (Core) **October/November 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 **16** pages. Any blank pages are indicated.

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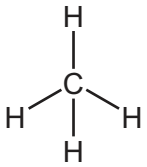
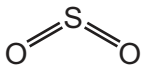
1 The structures of seven compounds, **A**, **B**, **C**, **D**, **E**, **F** and **G**, are shown.

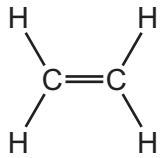
A



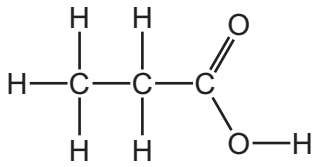
B



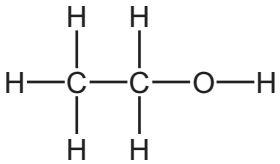
C



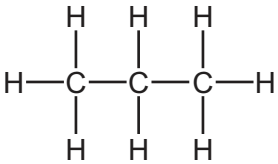
D



E



F



G

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

(a) State which structure, **A**, **B**, **C**, **D**, **E**, **F** or **G**, represents:

(i) a compound that contributes to acid rain

..... [1]

(ii) a product of respiration

..... [1]

(iii) a hydrocarbon that decolourises aqueous bromine

..... [1]

(iv) a carboxylic acid

..... [1]

(v) a compound that is the main constituent of natural gas.

..... [1]

(b) Compound **C** can be produced by cracking the kerosene fraction of petroleum.

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

.....

..... [2]

(ii) Complete the chemical equation for the cracking of $C_{13}H_{28}$ to form C_8H_{18} and one other hydrocarbon.

$$C_{13}H_{28} \rightarrow C_8H_{18} + \text{.....}$$ [1]

[Total: 8]

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2 **(a)** The table compares the percentage by mass of the elements in the whole Earth and in the Earth's crust.

element	percentage by mass in the whole Earth	percentage by mass in the Earth's crust
aluminium	1.20	8.20
calcium	1.10	3.60
iron	34.60	5.00
magnesium	12.70	2.00
oxygen	29.50	46.60
silicon	15.20	29.50
sodium	0.60	2.80
titanium	0.10	0.55
other elements		1.75
total	100.00	100.00

Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of the other elements in the whole Earth.

..... [1]

(ii) State which element is present in the whole Earth in the greatest percentage by mass.

..... [1]

(iii) Give **two** major differences in the composition of the whole Earth and the Earth's crust.

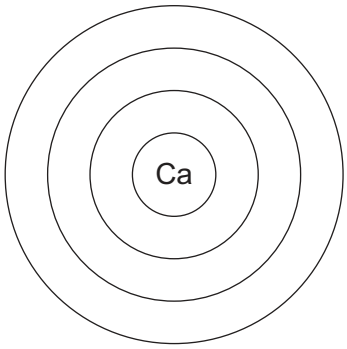
1 .....

.....

2 .....

.....
[2]

(b) Complete the diagram to show the electron arrangement in a calcium atom.



[2]

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(c) Iron is extracted from iron ore.

(i) Name an ore of iron.

..... [1]

(ii) Iron ore contains iron(III) oxide.
Iron(III) oxide is reduced by carbon monoxide in a blast furnace.

Complete the chemical equation for this reaction.

$$Fe_2O_3 + 3CO \rightarrow .....Fe + ...CO_2$$ [2]

(iii) Calcium carbonate is added to the blast furnace, where it undergoes thermal decomposition. Calcium oxide is formed.

State the meaning of the term *thermal decomposition*.

.....

..... [2]

(iv) Choose the correct statement about the reaction of calcium oxide in the blast furnace.

Tick (✓) **one** box.

- It reacts with carbon monoxide to form slag. ☐
- It reacts with carbon to form carbon dioxide and calcium. ☐
- It reacts with impurities in the iron ore to form slag. ☐
- It catalyses the removal of oxygen from iron(III) oxide. ☐

[1]

(v) State **one** advantage of recycling iron.

..... [1]

[Total: 13]

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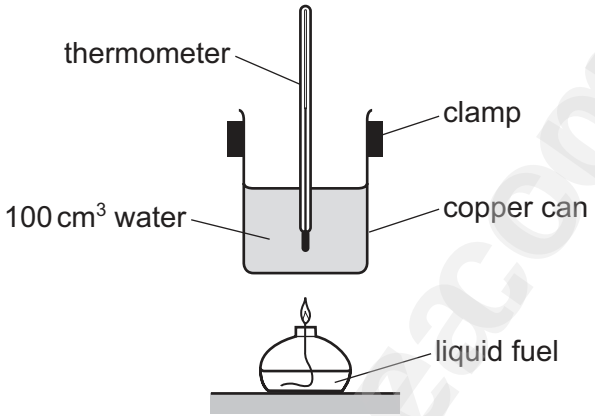
3 This question is about fuels and energy production.

(a) Name a fuel that is a solid at room temperature.

..... [1]

(b) The diagram shows the apparatus used to compare the energy released when 100 cm^3 of water is heated by burning different liquid fuels, **J**, **K**, **L** and **M**.



All conditions are kept the same, apart from the type of fuel and mass of fuel burned.

The results are shown.

fuel	mass of fuel burned / g	increase in temperature / °C
J	1	5
K	2	9
L	1	6
M	3	12

Deduce which fuel, **J**, **K**, **L** or **M**, releases the most energy per gram.

..... [1]

(c) Name the type of chemical reaction that releases heat energy.

..... [1]

(d) Name the **two** products formed when a hydrocarbon fuel undergoes complete combustion.

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

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(e) **(i)** Choose from the list the radioactive isotope used as a source of energy.

Draw a circle around your answer.

^{27}Al ^{23}Na ^{16}O ^{235}U [1]

(ii) State one **other** industrial use of radioactive isotopes.

..... [1]

[Total: 7]

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4 This question is about halogens.

(a) The table shows some properties of four halogens.

halogen	melting point in °C	boiling point in °C	density at room temperature and pressure in g/cm^3
fluorine	–220	–188	.....
chlorine	.....	–35	0.003
bromine	–7	59	3.12
iodine	114	184	4.93

(i) Complete the table by predicting:
- the melting point of chlorine
- the density of fluorine at room temperature and pressure.

[2]

(ii) Predict the physical state of fluorine at 0 °C.
Give a reason for your answer.

.....

..... [2]

(b) Fluorine reacts with water to produce hydrogen fluoride and oxygen.

(i) Complete the chemical equation for this reaction.

$$.....F_2 + 2H_2O \rightarrow .....HF + O_2$$ [2]

(ii) In this reaction both oxidation and reduction take place.

State the meaning of the term *oxidation*.

..... [1]

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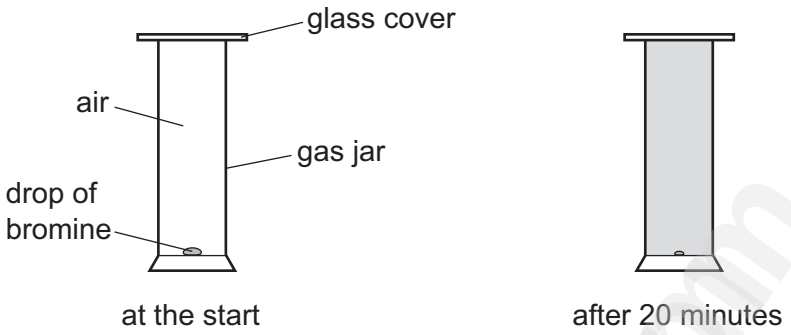
(c) Bromine is a red-brown liquid.
A drop of liquid bromine is placed in a gas jar.
After 20 minutes the red-brown colour has spread throughout the gas jar.



Explain these observations using the kinetic particle model.

.....

.....

.....

..... [3]

[Total: 10]

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5 This question is about compounds of nitrogen.

(a) Fertilisers containing nitrogen are used by farmers to improve crop growth.

Name two **other** elements found in most fertilisers that improve crop growth.

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

(b) Ammonium chloride, NH_4Cl, reacts with calcium hydroxide.
The products are ammonia, a salt and a liquid that turns anhydrous copper(II) sulfate blue.

Complete the word equation for this reaction.

ammonium chloride	+	calcium hydroxide	→	ammonia	+	....	+	.....

[2]

(c) Describe a test for chloride ions.

test .....

observations .....
[2]

(d) Bacteria in the soil can convert ammonium ions into oxides of nitrogen.

(i) Give one **other** source of oxides of nitrogen in the air.

..... [1]

(ii) State **one** adverse effect of oxides of nitrogen on health.

..... [1]

[Total: 8]

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6 This question is about acids, bases and salts.

(a) Describe the reaction of excess hydrochloric acid with zinc and with zinc oxide. Give the names of the products and any observations.

reaction with zinc

- products

..... and .....

- observations

.....

.....

reaction with zinc oxide

- products

..... and .....

- observations

.....

.....

[4]

(b) **(i)** Small pieces of zinc react with excess hydrochloric acid of different concentrations. The time taken for each reaction to finish is recorded.

The concentrations of each acid are:
- 0.5 mol / dm^3
- 1.0 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Complete the table by writing the concentrations in the first column.

concentration of acid in mol / dm^3	time taken for reaction to finish / s
	40
	20
	80

[1]

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(ii) Describe the effect on the time taken for the reaction to finish when it is carried out at a lower temperature.

All other conditions stay the same.

..... [1]

(c) Acids react with alkalis.

Choose the pH value which is alkaline.

Draw a circle around your answer.

pH 1 **pH 5** **pH 7** **pH 12** [1]

(d) State the colour change when excess hydrochloric acid is added to a solution of methyl orange in alkali.

from ..... to ..... [2]

(e) Soils where crops are grown can become acidic after fertilisers have been spread on the soil.

(i) Explain why controlling soil acidity is important.

..... [1]

(ii) Name a compound used to control soil acidity.

..... [1]

(f) Describe how to prepare pure dry crystals of sodium sulfate from an aqueous solution of sodium sulfate.

.....

.....

.....

..... [2]

[Total: 13]

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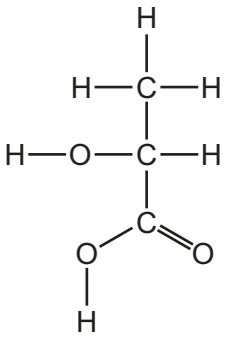
7 **(a)** The structure of lactic acid is shown.



(i) On the structure, draw a circle around the alcohol functional group. [1]

(ii) Deduce the formula of lactic acid to show the number of carbon, hydrogen and oxygen atoms.

..... [1]

(b) Ethanol is an alcohol.

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

ethane **ethene** **methane** **poly(ethene)**

Ethanol is manufactured by fermentation or from ..... . [1]

(ii) State **two** conditions needed for fermentation.

1 .....

2 .....
[2]

(iii) Ethanol is used in drinks and as a fuel.

State one **other** use of ethanol.

..... [1]

(iv) Name **one** physical property that can be used to determine if a sample of ethanol is pure or impure.

..... [1]

(c) Ethanol and methanol are in the same homologous series.

Explain the meaning of the term *homologous series*.

.....

.....
[2]

[Total: 9]

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8 This question is about metals.

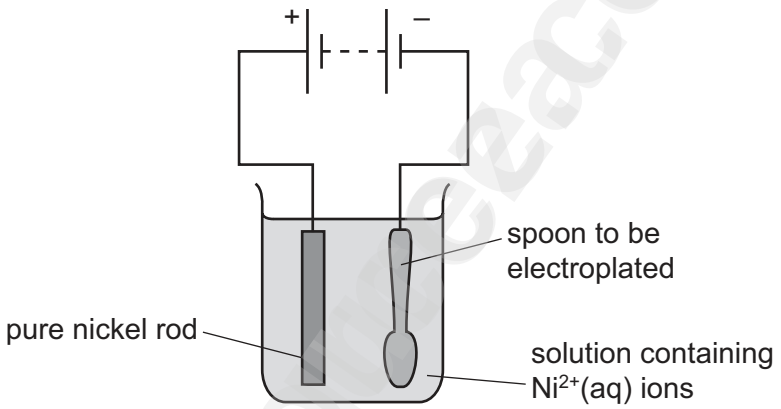
(a) Nickel is a transition element. Sodium is an element in Group I of the Periodic Table.
Nickel has a higher melting and boiling point than sodium.

Give two **other** ways in which the physical properties of nickel differ from the physical properties of sodium.

1 .....

2 .....
[2]

(b) A steel spoon can be electroplated with nickel.
The apparatus is shown.



(i) Choose a word from the list which describes the nickel rod.

Draw a circle around your answer.

anion **anode** **cathode** **cation** **electrolyte** [1]

(ii) Describe the observations made during this electroplating at the:

pure nickel rod .....

.....

spoon. .....

.....
[2]

(iii) State **one** reason for electroplating an object.

..... [1]

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(c) Deduce the number of electrons and neutrons in one atom of the isotope of nickel shown.

$^{62}_{28}Ni$

number of electrons .....

number of neutrons .....
[2]

(d) A compound of nickel has the formula NiC_4O_4.

Complete the table to calculate the relative molecular mass of NiC_4O_4.

atom	number of atoms	relative atomic mass	
nickel	1	59	1 × 59 = 59
carbon		12	
oxygen		16	

relative molecular mass = ... [2]

(e) The table shows the rates of reaction of four metals with steam.

metal	rate of reaction
magnesium	fast
nickel	slow
sodium	very fast
tin	very slow

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

[Total: 12]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 –		

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.).

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