Cambridge Assessment International Education

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CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0821428498

CHEMISTRY **0620/32**

Paper 3 Theory (Core) **February/March 2024**

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.

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1 A list of substances is shown.

brass
calcium oxide
carbon monoxide
diamond
glucose
hydrogen
litmus
magnesium bromide
methyl orange
sodium chloride
stainless steel
thymolphthalein
water
zinc oxide

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

State which substance:

(a) is formed by the thermal decomposition of calcium carbonate in the blast furnace

..... [1]

(b) is a mixture of copper and zinc

..... [1]

(c) turns yellow when an alkali is added

..... [1]

(d) is a reactant in photosynthesis

..... [1]

(e) is a salt that contains a positive ion with a charge of 1+

..... [1]

(f) is a compound that reduces iron(III) oxide in the blast furnace.

..... [1]

[Total: 6]

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2 Table 2.1 shows the masses of some of the ions in a 1000 cm^3 sample of river water.

Table 2.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of river water / mg
	NH_4^+	0.4
calcium	Ca^{2+}	1.4
chloride	Cl^-	0.1
hydrogencarbonate	HCO_3^-	1.2
magnesium	Mg^{2+}	0.6
nitrate	NO_3^-	0.8
phosphate	PO_4^{3-}	1.3
sodium	Na^+	0.5
	SO_4^{2-}	0.4

(a) Answer these questions using the information in Table 2.1.

(i) Name the negative ion that has the highest concentration.

..... [1]

(ii) Name the compound that contains NH_4^+ and SO_4^{2-} ions only.

..... [1]

(iii) Calculate the mass of hydrogencarbonate ions in 200 cm^3 of river water.

mass = ... mg [1]

(b) Give a test for sodium ions.

test .....

observations .....
[2]

(c) Most of the nitrate ions in river water come from fertilisers used on fields.

Describe the benefit of using fertilisers.

..... [1]

(d) Water from natural sources can be polluted with harmful substances.

State why sewage and phosphates in river water are harmful.

sewage .....

.....

phosphates .....

.....

[2]

(e) River water can contain acids such as ethanoic acid and methylbutanoic acid.

(i) Draw the displayed formula for ethanoic acid.

[1]

(ii) Ethanoic acid reacts with sodium hydroxide.

Complete the word equation for this reaction.

ethanoic acid	+	sodium hydroxide	→	....	+	.....

[2]

(iii) Methylbutanoic acid has the molecular formula $C_5H_{10}O_2$.

Complete Table 2.2 to calculate the relative molecular mass of $C_5H_{10}O_2$.

Table 2.2

atom	number of atoms	relative atomic mass	
carbon	5	12	$5 \times 12 = 60$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

[Total: 13]

3 The chemical elements are arranged in the Periodic Table in groups and periods.

(a) (i) Describe how the metallic character of the elements changes from left to right across a period.

.....

..... [1]

(ii) The elements in Group I are known as the alkali metals.

Describe **two** trends in the properties of the elements, going down Group I.

1 .....

2 .....

[2]

(b) Chlorine, bromine and iodine are in Group VII of the Periodic Table.

(i) Aqueous chlorine reacts with aqueous sodium bromide to produce aqueous bromine and aqueous sodium chloride.

Complete the symbol equation for this reaction.

$$C\mathit{l}_2 + ...NaBr \rightarrow ..... + 2NaC\mathit{l}$$ [2]

(ii) Suggest why aqueous iodine does **not** react with aqueous sodium bromide.

.....

..... [1]

(iii) Complete the dot-and-cross diagram in Fig. 3.1 for a molecule of iodine.

Show outer shell electrons only.

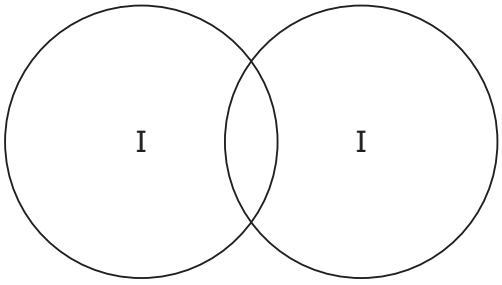

Fig. 3.1

[2]

(c) Molten silver bromide is electrolysed using graphite electrodes.

Name the product formed at each electrode.

product at the anode .....

product at the cathode .....
[2]

(d) Fig. 3.2 shows the apparatus used to electroplate a metal object with silver.

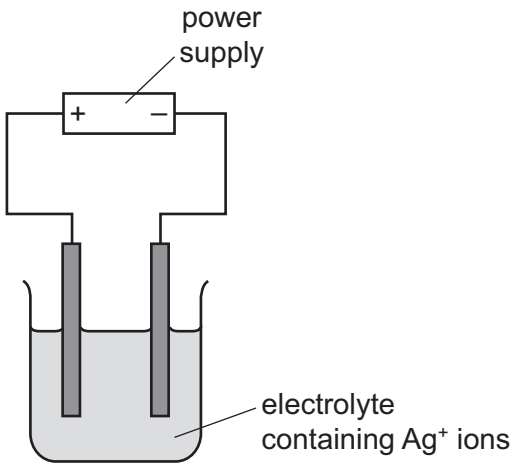

Fig. 3.2

(i) Label Fig. 3.2 to show where the silver is deposited. [1]

(ii) State why objects are electroplated.

..... [1]

[Total: 12]

4 Alkenes are a homologous series of hydrocarbons which are made by cracking larger alkane molecules.

(a) (i) Write the general formula for alkenes.

..... [1]

(ii) Explain the need for cracking larger alkane molecules.

.....

..... [1]

(iii) Describe **two** conditions needed for cracking.

1 .....

2 .....
[2]

(b) Alkenes are unsaturated compounds.

State the meaning of the term unsaturated.

.....

..... [1]

(c) Table 4.1 shows the boiling points of some alkenes.

Table 4.1

alkene	boiling point / °C
ethene	–104
propene	
butene	–6
pentene	30
hexene	63

(i) Predict the boiling point of propene.

..... °C [1]

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(ii) The melting point of butene is –185 °C.

Deduce the physical state of butene at –100 °C.

Give a reason for your answer.

physical state .....

reason .....

.....

[2]

(d) Fig. 4.1 shows a gas syringe that contains 60 cm^3 of ethene gas.

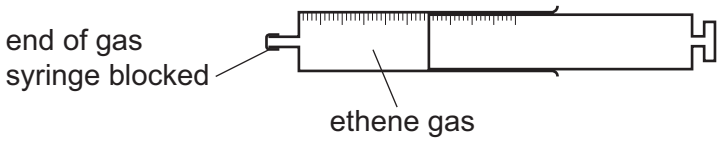

Fig. 4.1

State how the volume of ethene in the gas syringe changes when the temperature is decreased and the pressure remains the same.

..... [1]

(e) Poly(ethene) is produced by the polymerisation of ethene. The reaction is exothermic.

(i) State the meaning of the term exothermic.

..... [1]

(ii) Fig. 4.2 shows the reaction pathway diagram for this reaction.

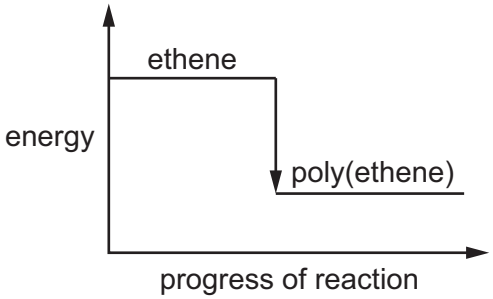

Fig. 4.2

Explain how this reaction pathway diagram shows that the reaction is exothermic.

.....

..... [1]

(f) Ethene reacts with steam to produce ethanol.

(i) Complete the symbol equation for this reaction.

C_2H_4 + ... → ..... [2]

(ii) Choose the word which describes the type of catalyst used in this reaction.

Draw a circle around your chosen answer.

acid **alkali** **metal** **salt** [1]

[Total: 14]

Question 5 starts on the next page.

5 Samarium is a metal.

(a) Deduce the number of electrons and neutrons in the samarium atom shown.

$^{154}_{62}Sm$

number of electrons .....

number of neutrons .....

[2]

(b) Samarium has properties that are similar to the properties of transition elements.

Choose **one** statement about samarium that is correct.

Tick (✓) **one** box.

Compounds of samarium are colourless.	☐
Samarium has a low melting point.	☐
Samarium and its compounds do **not** act as catalysts.	☐
Samarium has a high density.	☐

[1]

(c) Large pieces of samarium react with cold water to produce hydrogen gas.

$$2Sm + 6H_2O \rightarrow 2Sm(OH)_3 + 3H_2$$

(i) Complete Fig. 5.1 by drawing the apparatus to show how the volume of hydrogen gas is measured during this reaction.

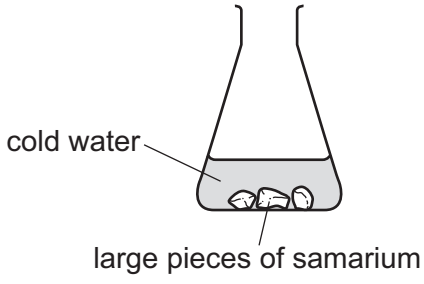

Fig. 5.1

[2]

(ii) The experiment is repeated using hot water instead of cold water.

All other conditions stay the same.

Describe how the rate of reaction changes when hot water is used.

..... [1]

(iii) The experiment is repeated using powdered samarium instead of large pieces of samarium.

All other conditions stay the same.

Describe how the rate of reaction changes when powdered samarium is used.

..... [1]

(d) Table 5.1 shows the observations when samarium and three other metals are heated in oxygen.

Table 5.1

metal	observations
nickel	reacts very slowly
samarium	reacts rapidly
strontium	reacts very rapidly
yttrium	does not react

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

least reactive ⟶ most reactive

[2]

(e) Samarium reacts with oxygen to produce samarium oxide, Sm_2O_3.

Complete the symbol equation for this reaction.

$$.....Sm + 3O_2 \rightarrow .....Sm_2O_3$$ [2]

(f) Hydrated samarium chloride is an ionic compound.

(i) Define the term hydrated.

.....

..... [1]

(ii) State **two** physical properties of an ionic compound.

1 .....

2 .....
[2]

[Total: 14]

Question 6 starts on the next page.

6 Sulfur is an element in Group VI of the Periodic Table.

(a) State the meaning of the term element.

.....

..... [1]

(b) Sulfur has a relative atomic mass of 32.

Complete these sentences about the relative atomic mass of sulfur using terms from the list.

^{12}C electrons ^{1}H isotopes neutrons ^{16}O protons ^{32}S

The relative atomic mass of sulfur is the average mass of the sulfur ..... .

This average mass is compared to 1/12th of the mass of an atom of ..... .

[2]

(c) Sulfur is a solid at room temperature and pressure.

Describe the motion and separation of the particles in solid sulfur.

motion .....

.....

separation .....

.....

[2]

(d) Liquid sulfur reacts with chlorine to produce disulfur dichloride.

$$2S + Cl_2 \rightarrow S_2Cl_2$$

(i) Describe how the general physical properties of a liquid differ from those of a solid. Give **two** differences.

1 .....

2 .....

[2]

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(ii) When 6.4 g of sulfur reacts with excess chlorine, 13.5 g of disulfur dichloride is produced.

Calculate the mass of disulfur dichloride produced when 19.2 g of sulfur reacts with excess chlorine.

mass = ... g [1]

(e) Sulfur dioxide is formed when sulfur burns in air.

(i) State the percentage of oxygen in clean, dry air.

..... [1]

(ii) State **one** source of the pollutant sulfur dioxide in the air other than from burning sulfur.

..... [1]

(iii) State **one** adverse effect of sulfur dioxide in the air.

..... [1]

(iv) State **one** method of reducing the emissions of sulfur dioxide.

..... [1]

(v) Sulfur dioxide dissolves in water to form sulfurous acid.

Give the formula of the ion that is present in all aqueous acids.

..... [1]

(vi) Sulfur dioxide reacts with oxygen in the presence of a catalyst to form sulfur trioxide. This is a reversible reaction.

Complete the equation for this reaction by writing the sign for a reversible reaction in the box.

$2SO_2 + O_2$ ☐ $2SO_3$ [1]

[Total: 14]

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[Turn over

7 Magnesium is an element in Group II of the Periodic Table.

(a) Deduce the electronic configuration of magnesium.

..... [1]

(b) Magnesium can be produced by reducing magnesium oxide with barium.

$$MgO + Ba \rightarrow Mg + BaO$$

Explain how this equation shows that magnesium oxide is reduced.

..... [1]

(c) Alloys of magnesium and aluminium are resistant to corrosion.

Choose the diagram, **A**, **B**, **C** or **D**, in Fig. 7.1 that best shows the structure of an alloy.

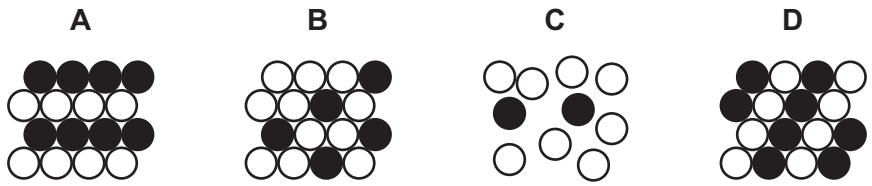

Fig. 7.1

diagram ..... [1]

(d) **(i)** Complete the word equation for the reaction of magnesium oxide with hydrochloric acid.

magnesium oxide	+	hydrochloric acid	→	....	+	.....

[2]

(ii) Magnesium oxide is insoluble in water.

Choose from the list one **other** compound that is insoluble in water.

Tick (✓) **one** box.

magnesium carbonate	☐
magnesium chloride	☐
magnesium nitrate	☐
magnesium sulfate	☐

[1]

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(e) Fig. 7.2 shows the electronic configuration of an element in Group II of the Periodic Table.

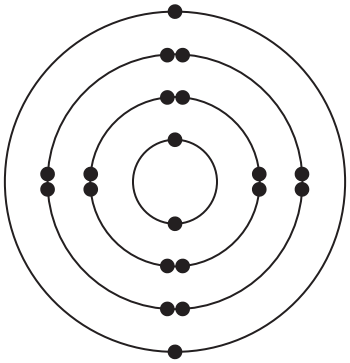

Fig. 7.2

Deduce the period in the Periodic Table to which this element belongs.

Period ..... [1]

[Total: 7]

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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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).