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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.

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]

2 Table 2.1 shows the masses of some of the ions in a 1000 cm³ 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 NH₄⁺ and SO₄²⁻ ions only.

..... [1]

(iii) Calculate the mass of hydrogencarbonate ions in 200 cm³ 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]

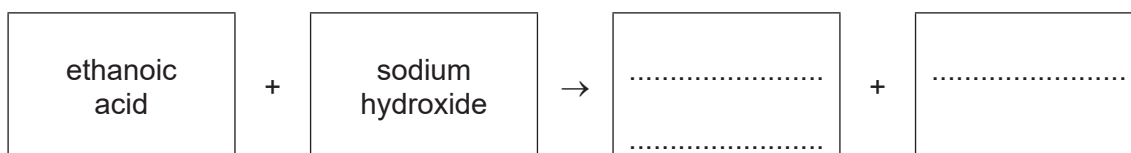
(e) River water can contain acids such as ethanoic acid and methylbutanoic acid.

(i) Draw the displayed formula for ethanoic acid.

[1]

(ii) Ethanoic acid reacts with sodium hydroxide.

Complete the word equation for this reaction.



[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.



(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.

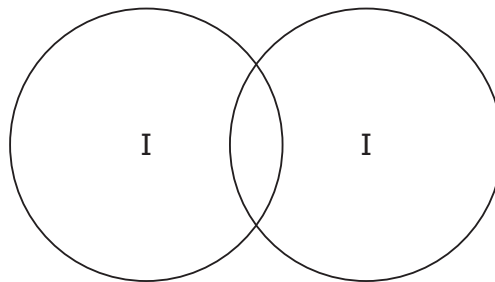


Fig. 3.1

[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.

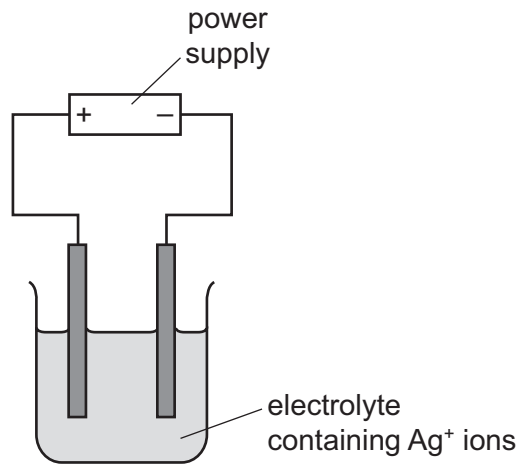


Fig. 3.2

(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]

- (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.

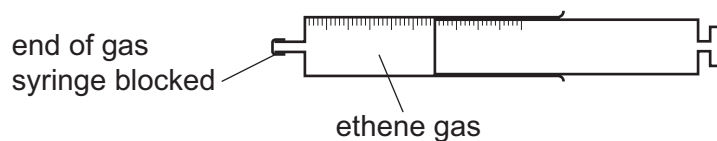


Fig. 4.1

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.

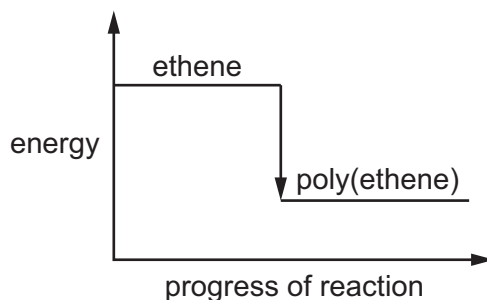


Fig. 4.2

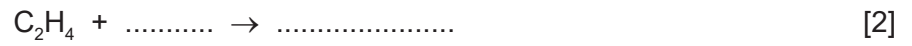
Explain how this reaction pathway diagram shows that the reaction is exothermic.

.....

..... [1]

(f) Ethene reacts with steam to produce ethanol.

(i) Complete the symbol equation for this reaction.



(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.



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.

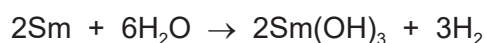
Samarium has a low melting point.

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.



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

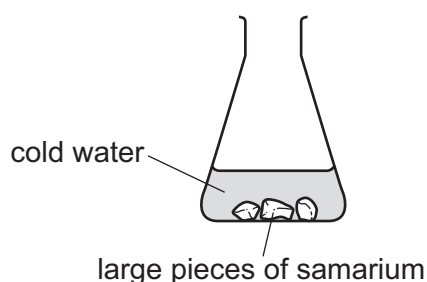


Fig. 5.1

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

--	--	--	--

[2]

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

Complete the symbol equation for this reaction.



- (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.

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

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

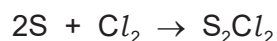
.....

separation

.....

[2]

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



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

1

2

[2]

- (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.



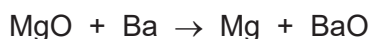
[Total: 14]

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.



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.

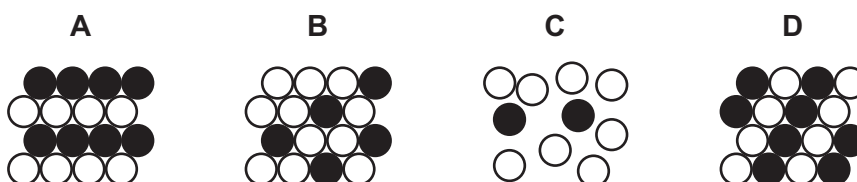


Fig. 7.1

diagram [1]

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



[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	<input type="checkbox"/>
magnesium chloride	<input type="checkbox"/>
magnesium nitrate	<input type="checkbox"/>
magnesium sulfate	<input type="checkbox"/>

[1]

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

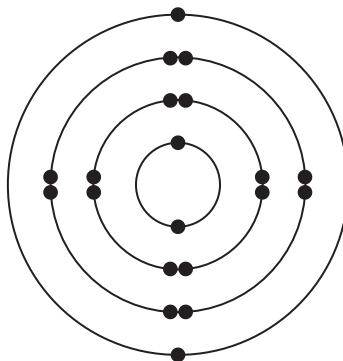


Fig. 7.2

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		Group						
		I	II	III	IV	V	VI	VII
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1</div> <div style="border: 1px solid black; padding: 2px;">2 He helium 4</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 7</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9</div> <div style="border: 1px solid black; padding: 2px;">5 B boron 11</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19</div> <div style="border: 1px solid black; padding: 2px;">10 Ne neon 20</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24</div> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> <div style="border: 1px solid black; padding: 2px;">18 Ar argon 40</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40</div> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 48</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 51</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 55</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 56</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 59</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 59</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 64</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65</div> <div style="border: 1px solid black; padding: 2px;">31 Ga gallium 70</div> <div style="border: 1px solid black; padding: 2px;">32 Ge germanium 73</div> <div style="border: 1px solid black; padding: 2px;">33 As arsenic 75</div> <div style="border: 1px solid black; padding: 2px;">34 Se selenium 79</div> <div style="border: 1px solid black; padding: 2px;">35 Br bromine 80</div> <div style="border: 1px solid black; padding: 2px;">36 Kr krypton 84</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 88</div> <div style="border: 1px solid black; padding: 2px;">39 Y yttrium 89</div> <div style="border: 1px solid black; padding: 2px;">40 Zr zirconium 91</div> <div style="border: 1px solid black; padding: 2px;">41 Nb niobium 93</div> <div style="border: 1px solid black; padding: 2px;">42 Mo molybdenum 96</div> <div style="border: 1px solid black; padding: 2px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 2px;">44 Ru ruthenium 101</div> <div style="border: 1px solid black; padding: 2px;">45 Rh rhodium 103</div> <div style="border: 1px solid black; padding: 2px;">46 Pd palladium 106</div> <div style="border: 1px solid black; padding: 2px;">47 Ag silver 108</div> <div style="border: 1px solid black; padding: 2px;">48 Cd cadmium 112</div> <div style="border: 1px solid black; padding: 2px;">49 In indium 115</div> <div style="border: 1px solid black; padding: 2px;">50 Sn tin 119</div> <div style="border: 1px solid black; padding: 2px;">51 Sb antimony 122</div> <div style="border: 1px solid black; padding: 2px;">52 Te tellurium 128</div> <div style="border: 1px solid black; padding: 2px;">53 I iodine 127</div> <div style="border: 1px solid black; padding: 2px;">54 Xe xenon 131</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">55 Cs caesium 133</div> <div style="border: 1px solid black; padding: 2px;">56 Ba barium 137</div> <div style="border: 1px solid black; padding: 2px;">57–71 lanthanoids</div> <div style="border: 1px solid black; padding: 2px;">72 Hf hafnium 178</div> <div style="border: 1px solid black; padding: 2px;">73 Ta tantalum 181</div> <div style="border: 1px solid black; padding: 2px;">74 W tungsten 184</div> <div style="border: 1px solid black; padding: 2px;">75 Re rhenium 186</div> <div style="border: 1px solid black; padding: 2px;">76 Os osmium 190</div> <div style="border: 1px solid black; padding: 2px;">77 Ir iridium 192</div> <div style="border: 1px solid black; padding: 2px;">78 Pt platinum 195</div> <div style="border: 1px solid black; padding: 2px;">79 Au gold 197</div> <div style="border: 1px solid black; padding: 2px;">80 Hg mercury 201</div> <div style="border: 1px solid black; padding: 2px;">81 Tl thallium 204</div> <div style="border: 1px solid black; padding: 2px;">82 Pb lead 207</div> <div style="border: 1px solid black; padding: 2px;">83 Bi bismuth 209</div> <div style="border: 1px solid black; padding: 2px;">84 Po polonium —</div> <div style="border: 1px solid black; padding: 2px;">85 At astatine —</div> <div style="border: 1px solid black; padding: 2px;">86 Rn radon —</div> </div>						
		<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 2px;">88 Ra radium —</div> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> <div style="border: 1px solid black; padding: 2px;">113 Nh nihonium —</div> <div style="border: 1px solid black; padding: 2px;">114 Fl flerovium —</div> <div style="border: 1px solid black; padding: 2px;">115 Mc moscovium —</div> <div style="border: 1px solid black; padding: 2px;">116 Lv livermorium —</div> <div style="border: 1px solid black; padding: 2px;">117 Ts tennessine —</div> <div style="border: 1px solid black; padding: 2px;">118 Og oganesson —</div> </div>						

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
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 —

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).