Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

B

CHEMISTRY **6092/02**

Paper 2

22 August 2023
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
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.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **12**.

The use of an approved scientific calculator is expected, where appropriate.

For examiner's use only:

B9	**/ 12**
B10	**/ 8**
B11 EITHER / OR	**/ 10**
Total	**/ 30**

This document consists of **12** printed pages.

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 The pH scale

The pH scale was developed in 1909 by Søren Sørensen to express the concentration of hydrogen ions.

The scale is important for a wide range of areas in everyday life, such as treating soil, reducing tooth decay, medicine, and monitoring the acidity of water.

The term ‘pH’ means ‘potential of hydrogen’, and the scale is the negative base 10 logarithm of the concentration of hydrogen ions in a solution.

$$pH = -\log_{10} [H^+]$$

where $[H^+]$ represents the concentration of hydrogen ions in a solution

The concentration of hydrogen ions, which are also known as ‘protons’, in a solution determines how acidic or basic the solution is. Since this concentration can vary drastically, a logarithmic scale is used. And since the scale is negative, the smaller the pH value, the higher the concentration of the ‘protons’.

The Universal Indicator

A Universal Indicator is a mixture of different types of indicators that displays several colour changes at various pH levels across the pH scale. It is used to detect the acidic or basic nature of a substance or a solution. It can be in the form of a paper strip or a solution.

The main components of a Universal Indicator, in the form of a solution, are thymol blue, methyl red, bromothymol blue and phenolphthalein.

Table 9.1

indicator	colour in lower pH range	pH range in which it changes colour	colour in upper pH range
thymol blue	red	1.2 to 2.8	yellow
	yellow	8.0 to 9.6	blue
methyl red	red	4.2 to 6.3	yellow
bromothymol blue	yellow	6.0 to 7.6	blue
phenolphthalein	colourless	8.0 to 10.5	pink

(a) Using ideas about sub-atomic particles, explain why a hydrogen ion is also known as a ‘proton’.

………

……… [1]

(b) Table 9.2 shows the pH value of a solution given the concentration of hydrogen ions.

Table 9.2

pH value	concentration of hydrogen ions in solution in mol/dm^3
1.3	0.0500
1.6	0.0250
1.9	0.0125
2.0	0.0100

(i) Determine the pH of a sample of 0.0250 mol/dm^3 of sulfuric acid.

[2]

(ii) A student claims that the pH value of a solution is inversely proportional to the concentration of hydrogen ions in a solution.

By means of a calculation, determine if the student’s claim is true or false.

[3]

(c) Secondary colours such as purple, orange and green can be made by mixing primary colours which are red, blue and yellow.

Red and blue make purple, red and yellow make orange, and yellow and blue make green.

(i) Using relevant information, explain why a solution of pH 3 turns the Universal Indicator orange.

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(ii) A student performed a titration experiment using dilute hydrochloric acid and aqueous sodium hydroxide.

The graph in Fig. 9.1 shows how the pH changes during his titration experiment.

The graph shows an equivalence point which occurs at pH 7.

The equivalence point is the point in a titration experiment at which the volume of titrant added from a burette is just enough to completely neutralise the solution in the conical flask.

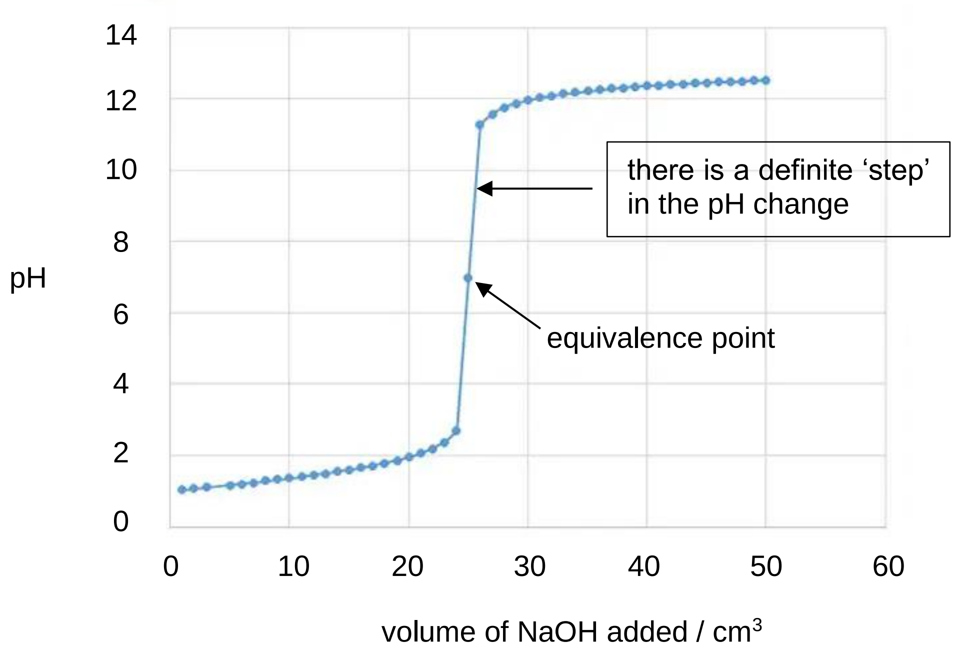

Fig. 9.1

An indicator is suitable to be used in a titration experiment if it fulfils the criteria below.

These include:

- has a narrow pH range in which it changes colour
- has a distinctive colour at lower pH and a different colour at higher pH
- changes colour only once during the titration
- pH range of indicator in which indicator changes colour falls within the definite 'step' of the reaction

Explain whether the Universal Indicator fulfils **each** of these criteria for the titration experiment above.

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[Total: 12]

B10 **(a)** Transition elements have variable oxidation states.

State two **other** properties typical of transition elements.

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(b) Figs. 10.1 to 10.3 show the 'dot-and-cross' diagrams of the compounds formed when an unidentified element J (not its actual chemical symbol) bonds with various elements.

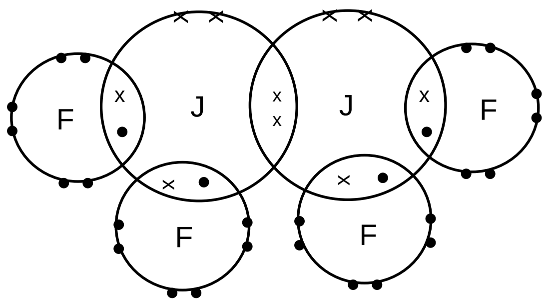

Fig. 10.1

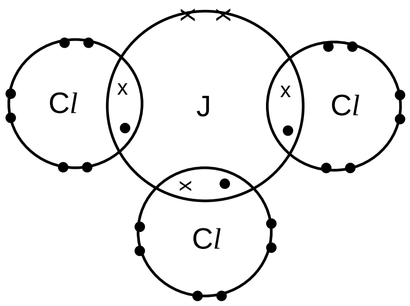

Fig. 10.2

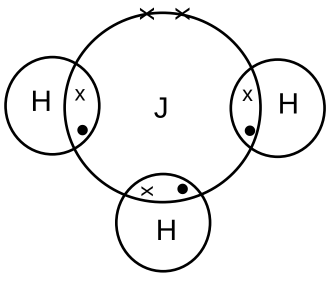

Fig. 10.3

(i) Determine the oxidation state of J in the various compounds.

chemical formula	oxidation state of J
J_2F_4	
JCl_3	
JH_3	

[2]

(ii) A student claims that since element J has variable oxidation states, J must be a transition element.

Give **two** pieces of evidence from Figs. 10.1 to 10.3 and your answer in **(b)(i)** which suggest that the student's claim is false.

Explain your reasoning.

evidence……………………………………………………………………………………

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reasoning…………………………………………………………………………………

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evidence……………………………………………………………………………………

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reasoning…………………………………………………………………………………

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[Total: 8]

EITHER

B11 Haematite, limestone and coke are heated together in a blast furnace in the manufacture of iron.

(a) Explain why each of the substances below are needed in a blast furnace.

limestone
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…….

coke………………………………………………………………………………………
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… [2]

(b) Scrap high carbon steel can be recycled to make pure iron. To remove the carbon impurities, oxygen is blown on the molten scrap high carbon steel in a large vessel known as a converter. The carbon impurities are removed as carbon dioxide.

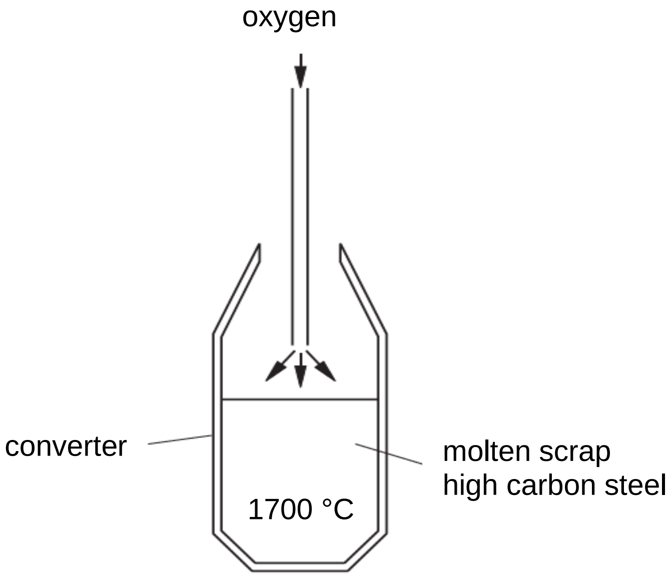

Fig. 11.1

(i) Write the chemical equation to show how carbon impurities from molten scrap high carbon steel are removed as carbon dioxide.

………..………………………………………………………………...…………………
.. [1]

(ii) The temperature of the molten scrap high carbon steel increases as oxygen is blown onto it. Explain why.

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.. [1]

(iii) Fig. 11.2 shows the arrangement of atoms in pure iron.

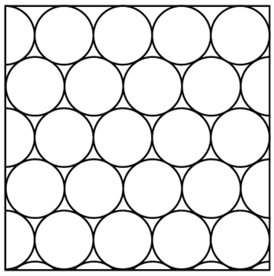

Fig. 11.2

Describe what changes to the diagram are necessary to show the arrangement of atoms in molten scrap high carbon steel as it was blown with oxygen.

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(c) Metals in the middle of the reactivity series such as iron and lead are extracted from their oxides by 'reduction reactions'.

Carbon or carbon monoxide can be used as reducing agents in the 'reduction reactions'.

Iron can be extracted by reacting its oxide with carbon monoxide in the blast furnace while lead can be extracted by reacting its oxide with carbon.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

$$PbO(s) + C(s) \rightarrow Pb(l) + CO(g)$$

(i) Explain, in terms of oxygen atoms, why the extraction of iron and lead from their oxides are known as 'reduction reactions'.

……………………………………………………………………………………………………

……………………………………………………………………………………………………. [2]

(ii) Describe an advantage of carbon monoxide as a reducing agent compared to carbon in ‘reduction reactions’.

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. [1]

[Total: 10]

OR

B11 Many carbonates thermally decompose to form carbon dioxide and an oxide.

Six 2.00 g samples of carbonates are heated strongly until there is no further change in mass.

Table 11.1 shows the mass of solid remaining at the end of the reaction.

Table 11.1

carbonate	mass before heating / g	mass remaining at the end / g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
1	2.00	0.95
2	2.00	2.00
3	2.00	1.30

(a) Using relevant information, determine which carbonate is the most thermally stable.

Explain your answer.

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……………………………………………………………………………………………………..

……………………………………………………………………………………………….. [2]

(b) The metal in carbonate 3 has an ionic charge of 2+.

By means of a calculation, identify carbonate 3.

[3]

(c) Explain why the mass remaining at the end of the reaction is different for each carbonate.

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…………………………………………………………………………………………………. [2]

(d) The carbonates of mercury and silver decompose to the metal on heating.

$$2HgCO_3 \rightarrow 2Hg + 2CO_2 + O_2$$

(i) Write the chemical equation to show the thermal decomposition of silver carbonate.

…………………………..…………………………………………………………..….. [1]

(ii) Suggest the position of mercury relative to copper in the reactivity series.

Explain your reasoning.

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…………………………………………………………………………………………... [2]

[Total: 10]

- End of Paper -

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								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.).