Student Number	
Mark / 48	

Chemistry

The Chemical Earth and Metals Modules Test • 2004

General Instructions

- Reading time – 5 minutes
- Working time – 55 minutes
- Write using black or blue pen
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- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper and may be removed for convenience
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Total Marks – 48

Part A – 12 marks
- Attempt Questions 1 – 12
- Allow about 10 minutes for this part

Part B – 36 marks
- Attempt Questions 13 – 28
- Allow about 45 minutes for this part

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Attempt Questions 1–12
Allow about 10 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

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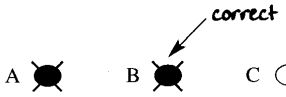

Answer Box for Questions 1– 12				
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2	A ○	B ○	C ○	D ○
3	A ○	B ○	C ○	D ○
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9	A ○	B ○	C ○	D ○
10	A ○	B ○	C ○	D ○
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► ***Mark your answers for Questions 1 – 12 in the Answer Box on page 3.***

1 Which element is found uncombined in the biosphere*?*

(A) Carbon
(B) Hydrogen
(C) Oxygen
(D) Neon

2 Which of the following elements has the smallest first ionisation energy*?*

(A) Lithium
(B) Sodium
(C) Fluorine
(D) Chlorine

3 The properties of elements X, M, Z and T were investigated and the results tabled…

Element	Malleability	Hardness	Electrical Conductivity (liquid state)
X	malleable	hard	high
M	brittle	soft	nil
Z	brittle	soft	high
T	brittle	hard	low

Choose the correct classification of elements X, M, Z and T based on the data.

	X	M	Z	T
(A)	metal	non–metal	carbon	semi–metal
(B)	non–metal	non–metal	carbon	metal
(C)	semi–metal	metal	carbon	semi–metal
(D)	metal	semi–metal	carbon	metal

4 Which of these substances does not exist as a molecule*?*

(A) $C_6H_{12}O_6$
(B) H_2
(C) He
(D) NaCl

5 Which of these compounds has the highest melting point?

(A) LiH
(B) SiH_4
(C) NH_3
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6 Which of the following is an application of gravimetric analysis?

(A) Determining the melting point of a metal alloy.
(B) Determining the salinity of the Murray River by testing its electrical conductivity.
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7 Which statement is correct for element X located in period 4 and group 7?

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Which list gives the correct order of the strength of bonds between the indicated ions?

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11 Which of these processes is used in the purification stage of producing pure, 99.96–99.99% copper?

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12 The table shows the properties and uses of four metal alloys…

Alloy	Properties	Uses
W	malleable	car bodies, pipes, nuts and bolts, roofing
X	hard and shock resistant	security safes, files, ball bearings
Y	resists corrosion, easily cast	ships' propellers, casting statues
Z	low melting point, adheres firmly to other metals when molten	joining metals together, applications in plumbing and electronics

Which alloy best describes the properties and uses of solder?

(A) W
(B) X
(C) Y
(D) Z

Part B – 36 marks
Attempt Questions 13 – 28
Allow about 45 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 13 (3 marks)

(a) Complete the table showing the existence of compounds on the Earth… **(2 marks)**

	Example of a compound found in the 'sphere
atmosphere	
biosphere	
hydrosphere	
lithosphere	

(b) Explain why uncombined elements are rare. **(1 mark)**

_____

_____

_____

Question 14 (2 marks)

Name these compounds…

Fe_2S_3	
$Fe(OH)_2$	
NO_2	
N_2O_4	

Question 15 (2 marks)

Chalcocite, a copper sulfide ore is converted into crude copper by a two–step process…

STEP 1 – _____ $Cu_2S_{(s)}$ + _____ $O_{2(g)}$ → _____ $Cu_2O_{(s)}$ + _____ $SO_{2(g)}$

STEP 2 – _____ $Cu_2O_{(s)}$ + _____ $C_{(s)}$ → _____ $Cu_{(s)}$ + _____ $CO_{2(g)}$

Balance each of the chemical equations. **(2 marks)**

Question 16 (4 marks)

Calcium reacts vigorously with sulfur producing calcium sulfide via an electron transfer reaction.

Complete the table detailing the process…

	Calcium atom	**+**	**Sulfur atom**	**→**	**Calcium ion**	**+**	**Sulfide ion**
Electronic configuration	***2–8–8–2***	**+**		**→**		**+**	
Lewis electron dot structure		**+**		**→**		**+**	

Question 17 (2 marks)

To separate the components of a mixture, differences in physical properties are used as the basis of the separation. Complete the table to illustrate this principle…

Separation Process	Physical property which enables the separation to occur
distillation	
evaporation	
filtration	
sieving	

Question 18 (2 marks)

For a Prac test, a student is given the task of separating a sample of water collected at Bondi Beach into its three components (water, salt and sand) and determining the mass percentage of each.

A student records this data after filtration and evaporation…

Mass of original sample	226.73 g
Mass of filter paper	1.33 g
Mass of filter paper + dry sand	28.08 g
Mass of salt recovered after evaporation	9.66 g

Calculate the percentage mass of water in the original sample.

Question 19 (3 marks)

Active metal, M, forms M^{2+} when it reacts.
Write balanced formulae equations for the reactions of metal, M, with…

(i) oxygen
(ii) water
(iii) hydrochloric acid

(i) _____

(ii) _____

(iii) _____

Question 20 (2 marks)

Explain why the formula for an ionic compound is an empirical formula.

_____

_____

_____

Question 21 (2 marks)

The reactions of metals with acids requires the transfer of electrons.

Write two half–equations to show the reaction between aluminium and sulfuric acid.

_____

_____

Question 22 (1 mark)

Identify **one** common element that exists as a covalent molecular structure and **one** common element that exists as a covalent network structure.

covalent molecule _____

covalent network _____

Question 23 (2 marks)

Identify and explain the trend in the atomic radius from left to right across the Periodic Table.

_____

_____

_____

_____

Question 24 (3 marks)

The table shows the melting points of the chlorides of seven consecutive elements A – F in a period of the Periodic Table…

Element	**A**	**B**	**C**	**D**	**E**	**F**
Melting point of the element's chloride (°C)	801	712	193	– 68	– 91	– 80

(a) Identify an element (A – F) which could be a metal. _____

(b) Identify the type of bonding which exists in the chlorides of elements A and B. _____

(c) Compare the electrical conductivity of the chlorides, A – F in the liquid state.

_____

_____

Question 25 (2 marks)

Mendeleev's model of the Periodic Table in 1869 was a landmark in the history of Chemistry.

(a) Describe how Mendeleev used the properties of the known elements to develop his model for the Periodic Table. **(1 mark)**

_____

_____

_____

(b) Identify one chemical property of iodine which confirms that it is a halogen and should be placed in group 7. **(1 mark)**

_____

_____

_____

Question 26 (2 marks)

In the lab this semester, you decomposed copper(II) carbonate by strongly heating it.
Write a (a) word equation and (b) a balanced formulae equation for the decomposition reaction.

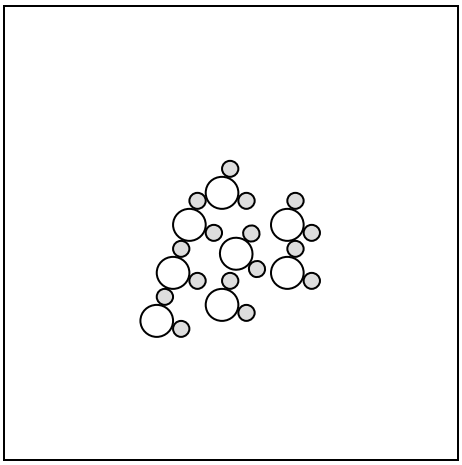
► *Assume the reactant is pure copper(II) carbonate.*

(a) _____

(b) _____

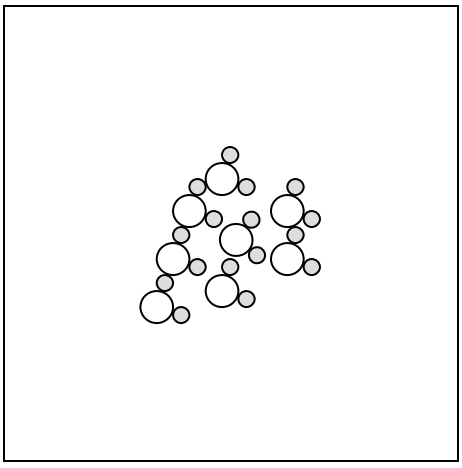
Question 27 (2 marks)

The diagrams on the left show eight water molecules in the liquid state.
Complete the diagram boxes on the right, showing the arrangement of particles after all the water molecules have undergone the processes of boiling and electrolysis.



BOILING

$\longrightarrow$



ELECTROLYSIS

$\longrightarrow$

Question 28 (2 marks)

(a) Identify one metal and one non–metal. **(1 mark)**

metal _____ *non–metal* _____

(b) Account for the use of ***either*** the metal ***or*** the non–metal you identified in terms of its ***physical properties***. **(1 mark)**

_____

_____

_____

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — Symbol of element — Atomic Weight — Name of element

Example: 79 Au 197.0 Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Answers and Marking Scheme

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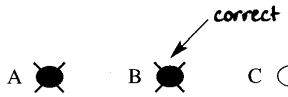

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Z	low melting point, adheres firmly to other metals when molten	joining metals together, applications in plumbing and electronics

Which alloy best describes the properties and uses of solder?

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(a) Complete the table showing the existence of compounds on the Earth… **(2 marks)**

	Example of a compound found in the 'sphere
atmosphere	***carbon dioxide***
biosphere	***glucose***
hydrosphere	***water***
lithosphere	***silicon dioxide***

(b) Explain why uncombined elements are rare. **(1 mark)**

The vast majority of elements are chemically reactive. They chemically react with other elements to form stable compounds achieving noble gas configurations with lower energy.

Question 14 (2 marks)

Name these compounds…

Fe_2S_3	***iron(III) sulfide***
$Fe(OH)_2$	***iron(II) hydroxide***
NO_2	***nitrogen dioxide***
N_2O_4	***dinitrogen tetroxide***

Question 15 (2 marks)

Chalcocite, a copper sulfide ore is converted into crude copper by a two–step process…

STEP 1 – $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

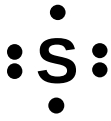
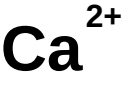
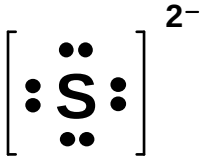
STEP 2 – $2Cu_2O + C \rightarrow 4Cu + CO_2$

Balance each of the chemical equations. **(2 marks)**

Question 16 (4 marks)

Calcium reacts vigorously with sulfur producing calcium sulfide via an electron transfer reaction.

Complete the table detailing the process…

	Calcium atom	**+**	**Sulfur atom**	**→**	**Calcium ion**	**+**	**Sulfide ion**
Electronic configuration	***2–8–8–2***	**+**	***2–8–6***	**→**	***2–8–8***	**+**	***2–8–8***
Lewis electron dot structure		**+**		**→**		**+**	

Question 17 (2 marks)

To separate the components of a mixture, differences in physical properties are used as the basis of the separation. Complete the table to illustrate this principle…

Separation Process	Physical property which enables the separation to occur
distillation	***boiling point***
evaporation	***boiling point***
filtration	***particle size*** ***solubility***
sieving	***particle size***

Question 18 (2 marks)

For a Prac test, a student is given the task of separating a sample of water collected at Bondi Beach into its three components (water, salt and sand) and determining the mass percentage of each.

A student records this data after filtration and evaporation…

Mass of original sample	**226.73 g**
Mass of filter paper	**1.33 g**
Mass of filter paper + dry sand	**28.08 g**
Mass of salt recovered after evaporation	**9.66 g**

Calculate the percentage mass of water in the original sample.

Mass of sand = 28.08 g – 1.33 g = 26.75 g (1 mark)

Mass of water = 226.73 g (sample) – 26.75 g (sand) – 9.66 g (salt) = 190.32 g

Percentage water = 190.32 g ÷ 226.73 g = 83.94%

Question 19 (3 marks)

Active metal, M, forms M^{2+} when it reacts.
Write balanced formulae equations for the reactions of metal, M, with…

(i) oxygen
(ii) water
(iii) hydrochloric acid

(i) $2M_{(s)} + O_{2\,(g)} \rightarrow 2MO_{\,(s)}$

(ii) $M_{(s)} + 2H_2O_{\,(l)} \rightarrow M(OH)_{2\,(aq)} + H_{2\,(g)}$

(iii) $M_{(s)} + 2HCl_{\,(aq)} \rightarrow MCl_{2\,(aq)} + H_{2\,(g)}$

Question 20 (2 marks)

Explain why the formula for an ionic compound is an empirical formula.

The empirical formula represents the simplest whole number ratio of atoms/ions of different elements in a compound. Ionic compounds are an infinite lattice/array of positive and negative ions and therefore the formula given to describe them is just the simplest ratio of ions in the array, i.e. the empirical formula.

Question 21 (2 marks)

The reactions of metals with acids requires the transfer of electrons.

Write two half–equations to show the reaction between aluminium and sulfuric acid.

$Al_{\,(s)} \rightarrow Al^{3+} + 3e^-$

$2H^+ + 2e^- \rightarrow H_{2\,(g)}$

Question 22 (1 mark)

Identify **one** common element that exists as a covalent molecular structure and **one** common element that exists as a covalent network structure.

covalent molecule ***e.g. hydrogen or H_2***

covalent network ***e.g. carbon (diamond)***

Question 23 (2 marks)

Identify and explain the trend in the atomic radius from left to right across the Periodic Table.

The atomic radii of elements decrease from left to right (1 mark) across the Periodic Table, as the nuclear charge increases. The greater the nuclear charge, the more the electron shells are attracted to the nucleus and the radius decreases. (1 mark)

Question 24 (3 marks)

The table shows the melting points of the chlorides of seven consecutive elements A – F in a period of the Periodic Table…

Element	**A**	**B**	**C**	**D**	**E**	**F**
Melting point of the element's chloride (℃)	801	712	193	– 68	– 91	– 80

(a) Identify an element (A – F) which could be a metal. ***A, B or C***

(b) Identify the type of bonding which exists in the chlorides of elements A and B. ***ionic***

(c) Compare the electrical conductivity of the chlorides, A – F in the liquid state.

Chlorides A – C would be electrolytes.
Chlorides D – F would be non–electrolytes.

Question 25 (2 marks)

Mendeleev's model of the Periodic Table in 1869 was a landmark in the history of Chemistry.

(a) Describe how Mendeleev used the properties of the known elements to develop his model for the Periodic Table. **(1 mark)**

Mendeleev studied the patterns in the elemental data and organised chemically similar elements in columns (groups).

OR

Mendeleev realised that the properties of elements were a periodic function of their atomic weights.

(b) Identify one chemical property of iodine which confirms that it is a halogen and should be placed in group 7. **(1 mark)**

Iodine (atoms) react in a 1:1 ratio with group one elements to form ionic iodides.

Question 26 (2 marks)

In the lab this semester, you decomposed copper(II) carbonate by strongly heating it.
Write a (a) word equation and (b) a balanced formulae equation for the decomposition reaction.
► *Assume the reactant is pure copper(II) carbonate.*

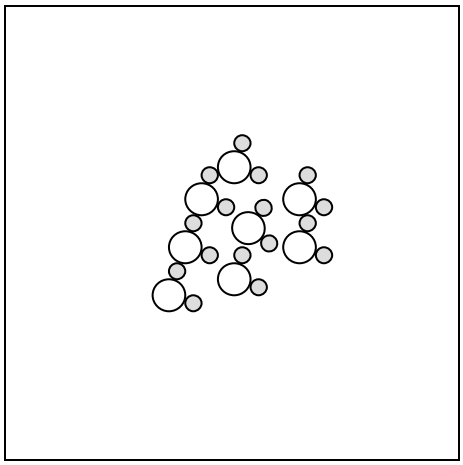
(a) ***copper(II) carbonate → copper(II) oxide + carbon dioxide***

(b) $CuCO_{3\,(s)} \rightarrow CuO_{(s)} + CO_{2\,(g)}$

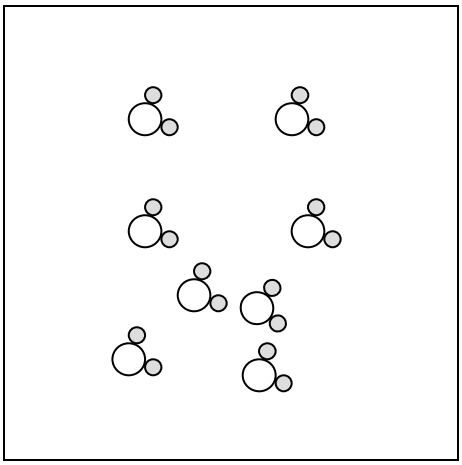
► ***Correct formulae including phase label required for 1 mark.***

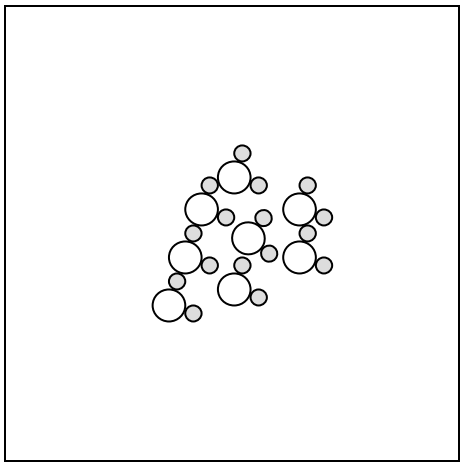
Question 27 (2 marks)

The diagrams on the left show eight water molecules in the liquid state.
Complete the diagram boxes on the right, showing the arrangement of particles after all the water molecules have undergone the processes of boiling and electrolysis.

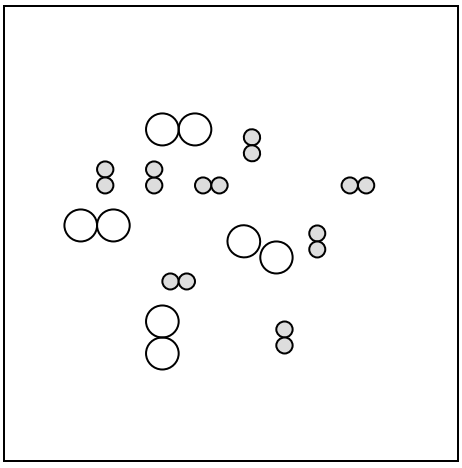


BOILING





ELECTROLYSIS



1 mark each for boiling and electrolysis
► ***Mass must be conserved in the transformation.***

Question 28 (2 marks)

(a) Identify one metal and one non–metal. **(1 mark)**

metal ***e.g. copper*** *non–metal* ***e.g. helium***

(b) Account for the use of ***either*** the metal ***or*** the non–metal you identified in terms of its ***physical properties***. **(1 mark)**

Copper is used as electrical wire due to its good electrical conductivity and ductility.

OR

Helium is used as a filler for balloons because of its low density.

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — Symbol of element — Atomic Weight — Name of element

Example: 79 Au 197.0 Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.