NAME:	CLASS:	INDEX NO:

QUEENSWAY SECONDARY SCHOOL

MID YEAR EXAMINATION 2019

SECONDARY 3 EXPRESS

Parent's Signature:

SCIENCE (PHYSICS, CHEMISTRY) 5076/01_03
SCIENCE (CHEMISTRY, BIOLOGY) 5078/01_03

15 May 2019

1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and index number 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 A: Multiple Choice Questions (20 marks)
For each question, there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Section B: Structured Questions (40 marks)
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 17.

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

For Examiner's Use		
	Actual	Converted
Section A	/ 20	-
Section B	/ 40	-
TOTAL	/ 60	/ 50%

This document consists of **17** printed pages.

Setters: Mr Glynn Tan, Mr Winston Fong

[Turn over

SECTION A

The total mark for this section is 20.

1 Gas **L** is less dense than air and is soluble in water.

There are four common methods to collect gases:

I displacement of water
II using a gas syringe
III upward displacement of air
IV downward displacement of air

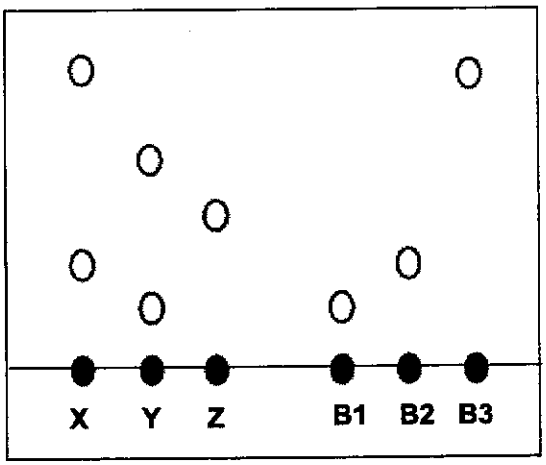
Which of the four methods above is/are suitable to collect gas **L**?

A **I**, **II** and **III**
B **I** and **IV**
C **II** and **III**
D **II** and **IV**

2 Which of the following apparatus is most appropriate to measure 35.0 cm^3 of a liquid?

A beaker
B burette
C conical flask
D pipette

3 Paper chromatography is used to test the urine samples (**X**, **Y** and **Z**) of three athletes to determine if banned substances (**B1**, **B2** and **B3**) are present in the urine samples.



Which of the urine samples contain(s) banned substances?

A none of the samples
B **X** only
C **X** and **Y**
D **Y** and **Z**

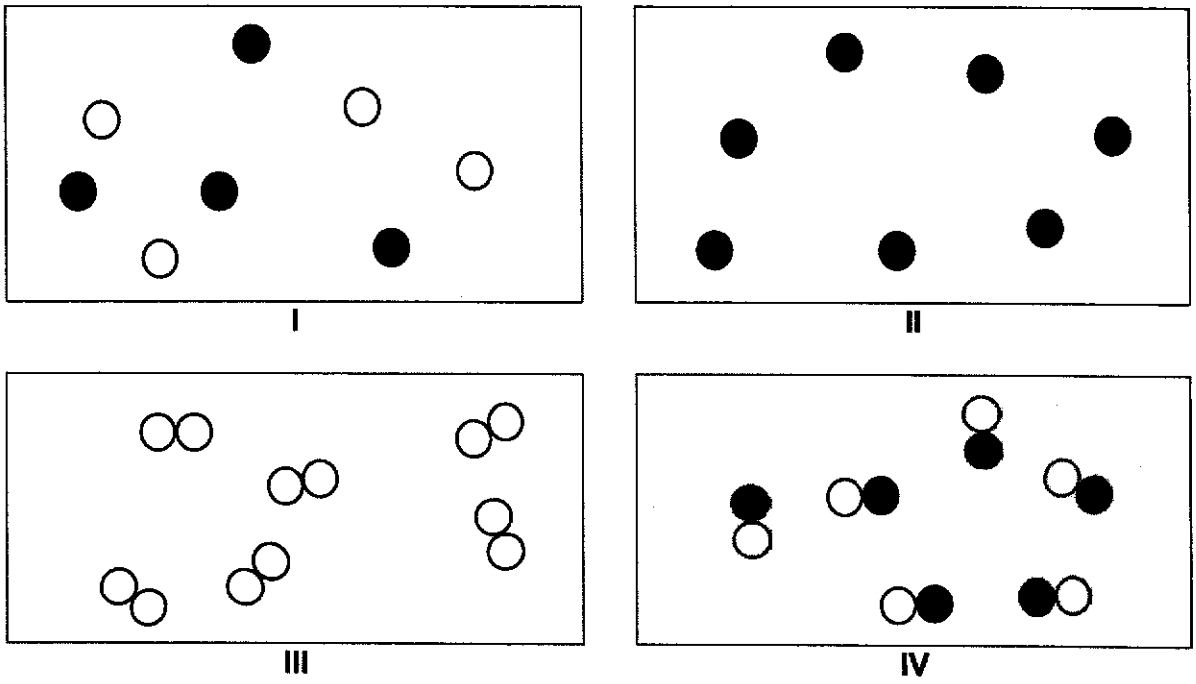
4 Excess water is added to a mixture of two solids. The resulting suspension is stirred and filtered. After filtration, a white residue and blue filtrate are obtained.

solid	colour	solubility in water
W	blue	soluble
X	blue	insoluble
Y	white	soluble
Z	white	insoluble

Using information in the table provided, which two solids were present in the mixture?

A **W** and **Y**
B **W** and **Z**
C **X** and **Y**
D **X** and **Z**

5 Which of the following substances are pure?



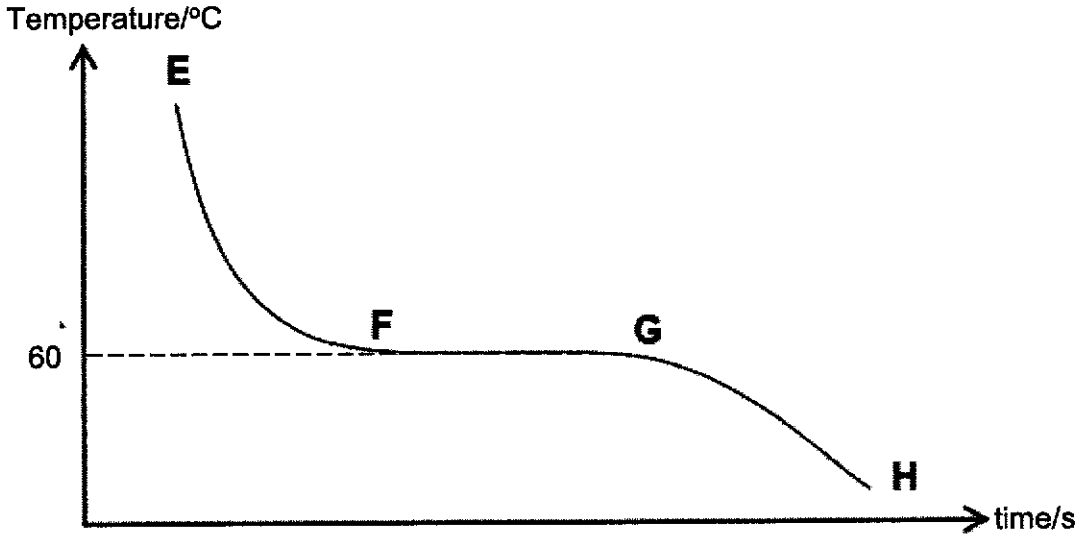
A **I** and **IV** only
B **II** and **III** only
C **II** and **IV** only
D **II, III** and **IV** only

6 At −100 °C, the particles of a substance vibrate about fixed positions. At 1000 °C, the particles of the same substance are able to slide over one another.

Which of the following could be the melting and boiling points of the substance described above?

	melting point / °C	boiling point / °C
A	−110	−35
B	−40	350
C	800	1450
D	1440	2600

7 A solid substance is heated until it has completely melted. The molten substance is then allowed to cool, as shown in the cooling curve below.



Which of the following statements must be true?

A From **E** to **F** and from **G** to **H**, the particles of the substance take in energy.
B From **F** to **G**, the average distance between particles decreases.
C The substance has a boiling point of 60 °C.
D The substance is impure.

8 Which of the following elements is made up of atoms with the greatest number of electron shells?

A fluorine
B magnesium
C neon
D potassium

9 The number of neutrons in the atoms of four elements (**K** to **N**) and their corresponding nucleon numbers are shown below.

element	number of neutrons in atom	nucleon number
K	2	4
L	10	19
M	10	20
N	13	25

Which elements are in the same Group of the Periodic Table?

A **K** and **L**
B **K** and **M**
C **K** and **N**
D **L** and **M**

10 The formulae of four ions are shown below.

O^{2-} F^{-} Na^{+} Be^{2+}

Which statement about these ions is correct?

A They all do not form compounds as they have fully filled valence electron shells.
B They all have the same number of electron shells.
C They all have the same number of valence electrons.
D They all have fully-filled valence electron shells.

11 Two atoms, **X** and **Y**, have the chemical symbols ${}^{6}_{3}X$ and ${}^{7}_{3}Y$ respectively.

Which of the following statements is true?

A **X** and **Y** are atoms of the same element with different numbers of neutrons.
B **X** and **Y** are atoms of different elements with different numbers of neutrons.
C **X** and **Y** have similar physical properties but different chemical properties.
D **X** and **Y** have different physical and chemical properties.

12 Elements **Y** and **Z** form an ionic compound of formula **YZ**.

What could the proton numbers of **Y** and **Z** be?

	Y	Z
A	1	9
B	9	11
C	13	7
D	17	9

13 Magnesium oxide has a higher melting point than sodium oxide.

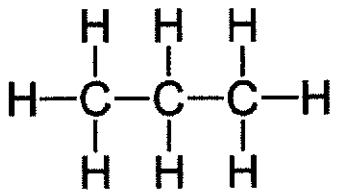
Which of the following statements best explains why this is so?

A Magnesium is from Group II whilst sodium is from Group I.
B Magnesium oxide has a greater charge than sodium oxide.
C Magnesium oxide has a greater relative formula mass than sodium oxide.
D Magnesium and oxide ions attract each other more strongly than sodium and oxide ions.

14 Which of the following pairs of elements forms a compound by sharing electrons?

A carbon and neon
B helium and hydrogen
C lithium and oxygen
D silicon and chlorine

15 The structural formula of propane, C_3H_8, is shown below.



In a molecule of propane, how many electrons are involved in bonding?

A 10
B 18
C 20
D 26

16 What is the chemical formula of sodium nitrate?

A $NaNO_3$
B Na_2NO_3
C $NaNO_3^-$
D $Na^+NO_3^-$

17 An unbalanced chemical equation is shown below.

$$wFe_2O_3 + xCO \rightarrow yFe + zCO_2$$

Which values of **w**, **x**, **y** and **z** would balance the chemical equation?

	w	x	y	z
A	1	3	2	3
B	1	4	2	4
C	2	3	1	3
D	2	4	1	4

18 Which of these correctly defines relative molecular mass?

A The average mass of 1 atom of a substance compared with 1/12 the mass of a carbon-12 atom.
B The average mass of 1 atom of a substance compared with 1/12 the mass of 1 mole of carbon-12.
C The average mass of 1 molecule of a substance compared with 1/12 the mass of a carbon-12 atom.
D The average mass of 1 molecule of a substance compared with 1/12 the mass of 1 mole of carbon-12.

19 Which of the following substances has the largest relative molecular or formula mass?

A Copper(II) carbonate, $CuCO_3$
B Phosphorus(V) oxide, P_2O_5
C Sodium hydroxide, NaOH
D Sulfuric acid, H_2SO_4

20 Which of the following gives the greatest number of moles?

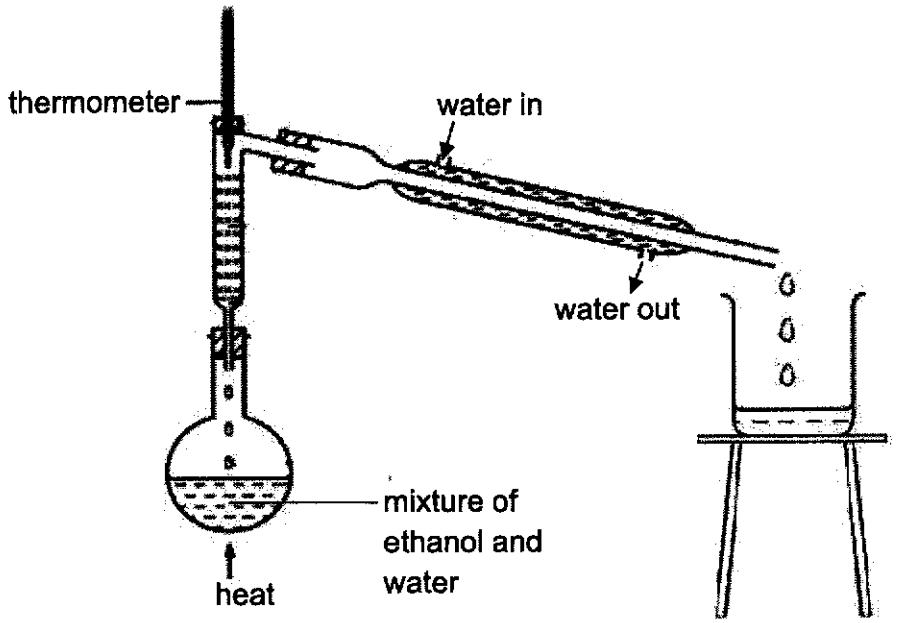
A 72 dm^3 of ammonia gas
B 100 g of calcium carbonate
C 6.0×10^{23} ions of sodium
D 1.2×10^{24} atoms of neon

END OF SECTION A

SECTION B

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 40.

B1 The set-up shown below is used to separate a mixture of ethanol and water.



(a) Name the separation technique shown.

.....[1]

(b) Suggest why ethanol and water can be separated using the set-up above.

.....

.....[1]

(c) Identify a mistake in the set-up above and suggest a suitable modification.

.....

.....

.....

.....

.....[2]

(d) As ethanol and water are being separated, name the main physical change occurring inside the round-bottomed flask.

.....

.....[1]

(e) How can the student make use of the set-up shown to determine if the ethanol or water collected is pure?

.....

.....[1]

B2 The boxes below contain descriptions of four different substances, **W**, **X**, **Y** and **Z**.

W, a colourless substance at room temperature, has a fixed composition. **W** has a melting point of 10 °C, and a boiling point of 80 °C.	**X**, a colourless gas, burns in air to produce carbon dioxide and water only.
Y is an unreactive gas consisting only of single atoms, with a boiling point of −220 °C.	**Z**, a blue liquid, can be separated by simple distillation to obtain a colourless liquid, and blue crystals.

(a) Decide whether each substance should be classified as an element, compound, mixture, or either an element or a compound. Place a tick (✓) in the correct box for each substance in the table below.

substance	element	compound	mixture	either an element or a compound
W				
X				
Y				
Z				

[4]

(b) Which of the four substances is a noble gas? Explain your answer.

.....

.....[2]

(c) Describe what happens to the distance, attraction, movement and energy between/of the particles in **W** when it is heated from 25 °C to 85 °C.

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.....[4]

B3 Nitrogen can be chemically combined with other elements such as lithium and fluorine.

(a) When nitrogen is chemically combined with lithium, lithium nitride, Li_3N, is formed.

Draw a "dot-and-cross" diagram to show how electrons are arranged in lithium nitride. Show only the outermost electrons.

[2]

(b) Nitrogen can also be chemically combined with fluorine to form nitrogen trifluoride, NF_3.

(i) Describe how a nitrogen atom combines with fluorine, in terms of the number of electrons gained, lost or shared.

.....

.....

.....

.....

.....[2]

(ii) Hence, draw a "dot-and-cross" diagram to show how electrons are arranged in nitrogen trifluoride. Show only the outermost electrons.

[2]

(c) Lithium nitride has a melting point of 813 °C while nitrogen trifluoride has a melting point of −207 °C.

By using ideas related to structure and bonding, explain why the melting points of both compounds are so different.

.....

.....

.....

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.....

.....[3]

B4 Pure zinc metal can be extracted from solid zinc blende, ZnS, via a two-step reaction described below.

Step 1: Zinc blende is roasted in excess oxygen. The oxygen reacts with the zinc blende to produce solid zinc oxide and gaseous sulfur dioxide.

Step 2: Zinc oxide is heated in the presence of solid carbon to obtain zinc metal and carbon monoxide.

(a) Write balanced chemical equations for the two steps used in the extraction of zinc. Include state symbols in your answer.

Step 1: .....

Step 2: .....[4]

(b) 97 tonnes of zinc blende was reacted with excess oxygen. The resulting zinc oxide was reacted with excess carbon to obtain zinc.

(1 tonne = 1 X 10^6 g)

Calculate

(i) the number of moles of zinc blende which was used.

.....

.....[1]

(ii) the number of moles of zinc oxide which was produced from the reaction between zinc blende and oxygen.

If you were unable to complete **(a)**, you may assume that 1 mole of zinc blende produces 2 moles of zinc oxide.

.....

.....[1]

(iii) the mass of carbon which was required to completely react with the zinc oxide.

If you were unable to complete **(a)**, you may assume that zinc oxide and carbon react in a 2:1 ratio.

.....

.....[1]

(iv) the mass of zinc which was extracted at the end of the reaction.

If you were unable to complete **(a)**, you may assume that zinc oxide and carbon react in a 2:1 ratio.

.....

.....[1]

B5 A white solid is known to be a mixture of zinc carbonate and sodium carbonate.

(a) To find the percentage by mass of zinc carbonate in the mixture, 5.0 g of the mixture was heated strongly until no further changes were observed.

When zinc carbonate is heated strongly, it decomposes according to the equation below.

$$ZnCO_3 \rightarrow ZnO + CO_2$$

However, when sodium carbonate is heated strongly, it does not decompose.

When the heating had completed, 0.48 dm^3 of carbon dioxide gas had been produced.

Calculate

(i) the number of moles of carbon dioxide which was produced from heating the mixture.

.....

.....[1]

(ii) the mass of zinc carbonate present in the mixture.

.....

.....[1]

(iii) the percentage by mass of zinc carbonate in the mixture.

.....

.....[1]

(b) 1.25 g of solid zinc carbonate was reacted with excess dilute nitric acid to produce aqueous zinc nitrate, carbon dioxide and water.

(i) Write the ionic equation for the reaction of solid zinc carbonate with dilute nitric acid.

.....[2]

(ii) A 100 cm^3 gas syringe was used to collect the carbon dioxide produced in this reaction.

By calculating the volume of carbon dioxide produced in this reaction, show that the volume of the syringe would be insufficient to contain the carbon dioxide produced.

(1 dm^3 = 1000 cm^3)

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.....[2]

END OF PAPER

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							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 –		

Key: proton (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.).

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SECTION A

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1 Gas L is less dense than air and is soluble in water.

There are four common methods to collect gases:

I displacement of water
II using a gas syringe
III upward displacement of air
IV downward displacement of air

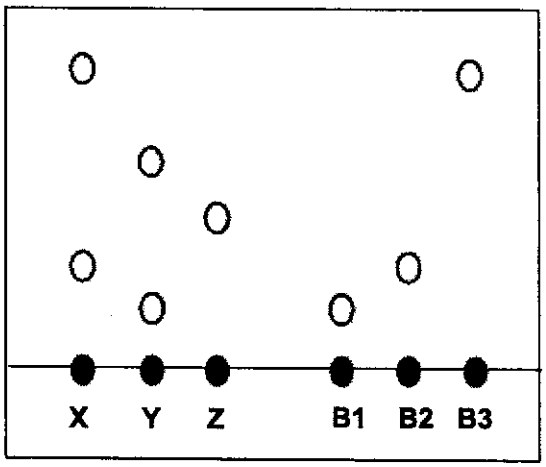
Which of the four methods above is/are suitable to collect gas L?

A I, II and III
B I and IV
[redacted]
D II and IV

2 Which of the following apparatus is most appropriate to measure 35.0 cm^3 of a liquid?

A beaker
[redacted]
C conical flask
D pipette

3 Paper chromatography is used to test the urine samples (**X**, **Y** and **Z**) of three athletes to determine if banned substances (**B1**, **B2** and **B3**) are present in the urine samples.



Which of the urine samples contain(s) banned substances?

A none of the samples
B X only
[redacted]
D Y and Z

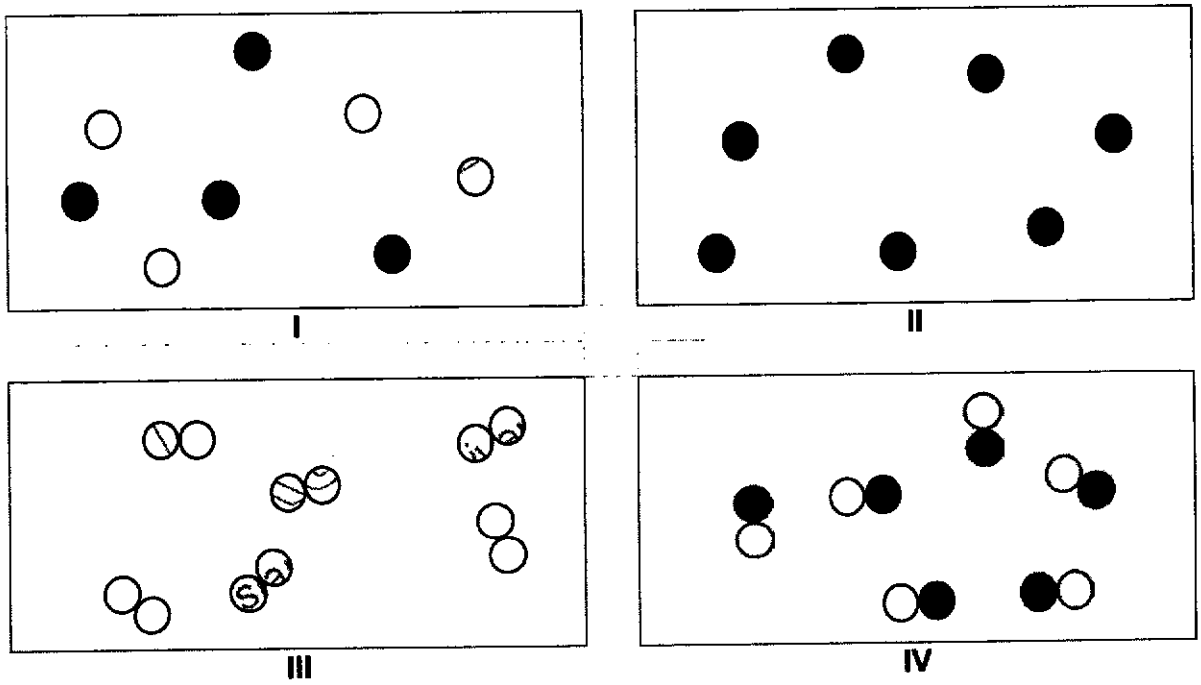
4 Excess water is added to a mixture of two solids. The resulting suspension is stirred and filtered. After filtration, a white residue and blue filtrate are obtained.

solid	colour	solubility in water
W	blue	soluble
X	blue	insoluble
Y	white	soluble
Z	white	insoluble

Using information in the table provided, which two solids were present in the mixture?

A **W** and **Y**
B [redacted]
C **X** and **Y**
D **X** and **Z**

5 Which of the following substances are pure?



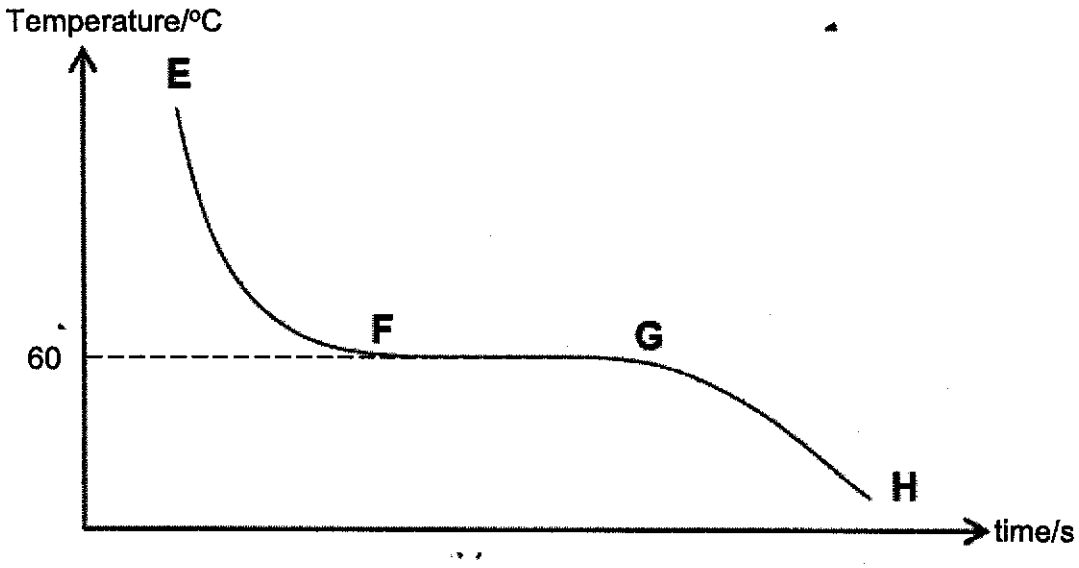
A **I** and **IV** only
B **II** and **III** only
C **II** and **IV** only
D [redacted]

6 At −100 °C, the particles of a substance vibrate about fixed positions. At 1000 °C, the particles of the same substance are able to slide over one another.

Which of the following could be the melting and boiling points of the substance described above?

	melting point / °C	boiling point / °C
A	−110	−35
B	−40	350
[redacted]	[redacted]	[redacted]
D	1440	2600

7 A solid substance is heated until it has completely melted. The molten substance is then allowed to cool, as shown in the cooling curve below.



Which of the following statements must be true?

A From **E** to **F** and from **G** to **H**, the particles of the substance take in energy.
[redacted]
C The substance has a boiling point of 60 °C.
D The substance is impure.

8 Which of the following elements is made up of atoms with the greatest number of electron shells?

A fluorine
B magnesium
C neon
[redacted]

9 The number of neutrons in the atoms of four elements (**K** to **N**) and their corresponding nucleon numbers are shown below.

element	number of neutrons in atom	nucleon number
K	2	4
L	10	19
M	10	20
N	13	25

Which elements are in the same Group of the Periodic Table?

A **K** and **L**
[redacted]
C **K** and **N**
D **L** and **M**

10 The formulae of four ions are shown below.

O^{2-} F^{-} Na^{+} Be^{2+}

Which statement about these ions is correct?

A They all do not form compounds as they have fully filled valence electron shells.
B They all have the same number of electron shells.
C They all have the same number of valence electrons.
[redacted]

11 Two atoms, **X** and **Y**, have the chemical symbols ${}^{6}_{3}X$ and ${}^{7}_{3}Y$ respectively.

Which of the following statements is true?

[redacted]
B **X** and **Y** are atoms of different elements with different numbers of neutrons.
C **X** and **Y** have similar physical properties but different chemical properties.
D **X** and **Y** have different physical and chemical properties.

12 Elements **Y** and **Z** form an ionic compound of formula **YZ**.

What could the proton numbers of **Y** and **Z** be?

	Y	Z
A	1	9
B	9	11
[redacted]	[redacted]	[redacted]
D	17	9

13 Magnesium oxide has a higher melting point than sodium oxide.

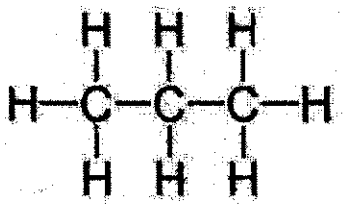
Which of the following statements best explains why this is so?

A Magnesium is from Group II whilst sodium is from Group I.
B Magnesium oxide has a greater charge than sodium oxide.
C Magnesium oxide has a greater relative formula mass than sodium oxide.
[redacted]

14 Which of the following pairs of elements forms a compound by sharing electrons?

A carbon and neon
B helium and hydrogen
C lithium and oxygen
[redacted]

15 The structural formula of propane, C_3H_8, is shown below.



In a molecule of propane, how many electrons are involved in bonding?

A 10
B 18
[redacted]
D 26

16 What is the chemical formula of sodium nitrate?

[redacted]
B Na_2NO_3
C $NaNO_3^-$
D $Na^+NO_3^-$

17 An unbalanced chemical equation is shown below.

$$\mathbf{w}Fe_2O_3 + \mathbf{x}CO \rightarrow \mathbf{y}Fe + \mathbf{z}CO_2$$

Which values of **w**, **x**, **y** and **z** would balance the chemical equation?

	w	x	y	z
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
B	1	4	2	4
C	2	3	1	3
D	2	4	1	4

18 Which of these correctly defines relative molecular mass?

A The average mass of 1 atom of a substance compared with 1/12 the mass of a carbon-12 atom.

B The average mass of 1 atom of a substance compared with 1/12 the mass of 1 mole of carbon-12.

[redacted]

D The average mass of 1 molecule of a substance compared with 1/12 the mass of 1 mole of carbon-12.

19 Which of the following substances has the largest relative molecular or formula mass?

A Copper(II) carbonate, $CuCO_3$

[redacted]

C Sodium hydroxide, NaOH

D Sulfuric acid, H_2SO_4

20 Which of the following gives the greatest number of moles?

[redacted]

B 100 g of calcium carbonate

C 6.0×10^{23} ions of sodium

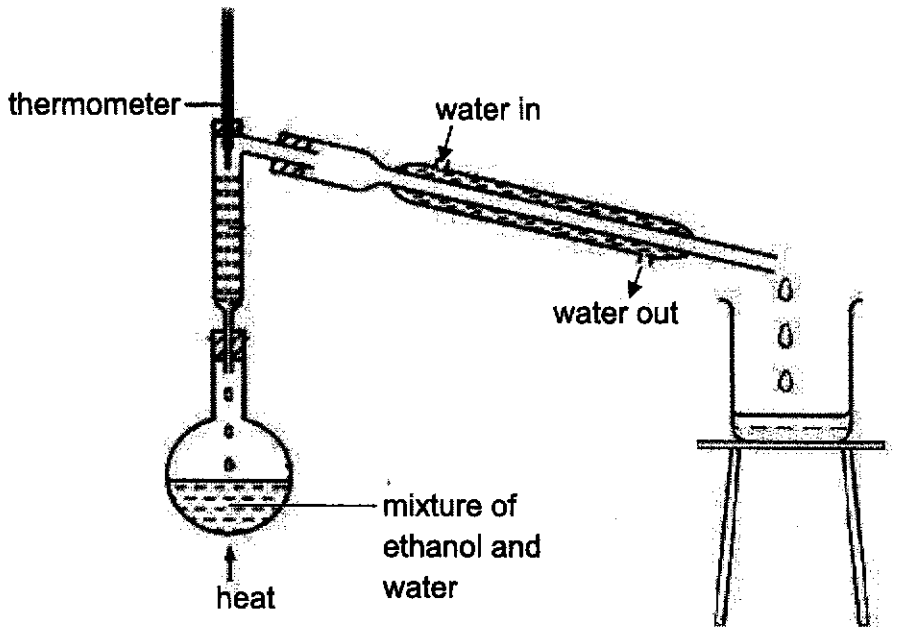
D 1.2×10^{24} atoms of neon

END OF SECTION A

SECTION B

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 40.

B1 The set-up shown below is used to separate a mixture of ethanol and water.



(a) Name the separation technique shown.
Fractional distillation [1]

Do not accept 'distillation'.

(b) Suggest why ethanol and water can be separated using the set-up above.
They have different boiling points. [1]

(c) Identify a mistake in the set-up above and suggest a suitable modification.
Water is entering the condenser from the top and leaving from the bottom. [1]
The direction of water entry and exit should be reversed. [1]

(d) As ethanol and water are being separated, name the main physical change occurring inside the round-bottomed flask.
Boiling [1]

Do not accept 'evaporation'.

(e) How can the student make use of the set-up shown to determine if the ethanol or water collected is pure?
Take the thermometer reading. If the liquid has a fixed boiling point, it is pure. [1]

B2 The boxes below contain descriptions of four different substances, **W**, **X**, **Y** and **Z**.

W, a colourless substance at room temperature, has a fixed composition. **W** has a melting point of 10 °C, and a boiling point of 80 °C.	**X**, a colourless gas, burns in air to produce carbon dioxide and water only.
Y is an unreactive gas consisting only of single atoms, with a boiling point of −220 °C.	**Z**, a blue liquid, can be separated by simple distillation to obtain a colourless liquid, and blue crystals.

(a) Decide whether each substance should be classified as an element, compound, mixture, or either an element or a compound. Place a tick (✓) in the correct box for each substance in the table below.

substance	element	compound	mixture	either an element or a compound
W				✓
X		✓		
Y	✓			
Z			✓	

[4]

(b) Which of the four substances is a noble gas? Explain your answer.
Y [1]
It exists as single atoms, showing that it must be a noble gas. [1]

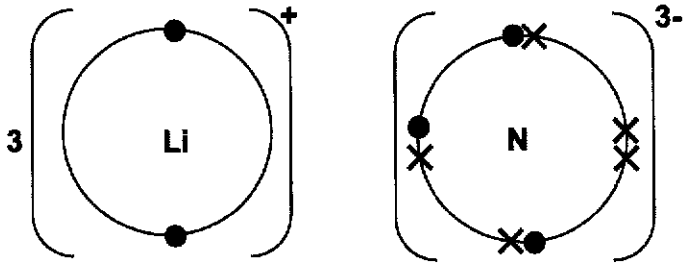
(c) Describe what happens to the distance, attraction, movement and energy between/of the particles in **W** when it is heated from 25 °C to 85 °C.
As liquid W boils,

Distance between the particles increases. [1]
Attractive forces between the particles decreases/weakens. [1]
Energy of the particles increases. [1]
Particles move quickly and randomly in all directions, from sliding past each other. [1]

B3 Nitrogen can be chemically combined with other elements such as lithium and fluorine.

(a) When nitrogen is chemically combined with lithium, lithium nitride, Li_3N, is formed.

Draw a "dot-and-cross" diagram to show how electrons are arranged in lithium nitride. Show only the outermost electrons.

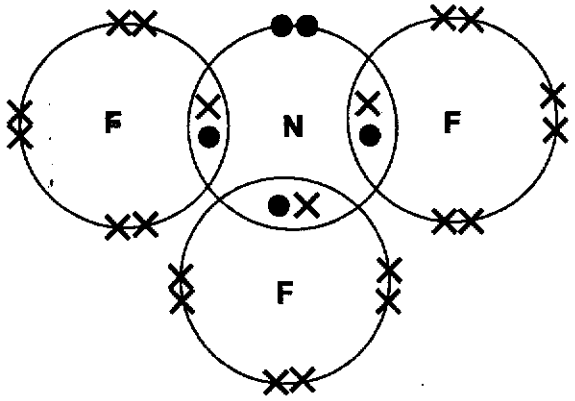


[1] – valence electrons correctly displayed
[1] – ionic charges and coefficients correctly displayed

(b) Nitrogen can also be chemically combined with fluorine to form nitrogen trifluoride, NF_3.

(i) Describe how a nitrogen atom combines with fluorine, in terms of the number of electrons gained, lost or shared.
Each nitrogen atom shares three electrons with fluorine atoms, and each fluorine atom shares one electron with a nitrogen atom. [1]
The end result is that all atoms have a fully-filled valence electron shell. [1]

(ii) Hence, draw a "dot-and-cross" diagram to show how electrons are arranged in nitrogen trifluoride. Show only the outermost electrons.



[1] – valence electrons correctly displayed
[1] – shared electrons correctly displayed

(c) Lithium nitride has a melting point of 813 °C while nitrogen trifluoride has a melting point of −207 °C.

By using ideas related to structure and bonding, explain why the melting points of both compounds are so different.
Strong electrostatic forces of attraction exist between oppositely charged ions in lithium nitride [1], whereas weak intermolecular forces of attraction are present in nitrogen trifluoride [1].
It takes a large amount of energy to overcome the strong electrostatic forces of attraction in lithium nitride and a small amount of energy to overcome the weak intermolecular forces of attraction in nitrogen trifluoride [1], (resulting in a high melting point for the former and a low melting point for the latter).

B4 Pure zinc metal can be extracted from solid zinc blende, ZnS, via a two-step reaction described below.

Step 1: Zinc blende is roasted in excess oxygen. The oxygen reacts with the zinc blende to produce solid zinc oxide and gaseous sulfur dioxide.

Step 2: Zinc oxide is heated in the presence of solid carbon to obtain zinc metal and carbon monoxide.

(a) Write balanced chemical equations for the two steps used in the extraction of zinc. Include state symbols in your answer.

Step 1: $2ZnS\ (s) + O_2\ (g) \rightarrow 2ZnO\ (s) + 2SO_2\ (g)$

Step 2: $ZnO\ (s) + C\ (s) \rightarrow Zn\ (s) + CO\ (g)$

For each equation:
[1] for correct chemical species and balancing
[1] for correct state symbols

(b) 97 tonnes of zinc blende was reacted with excess oxygen. The resulting zinc oxide was reacted with excess carbon to obtain zinc.

(1 tonne = 1×10^6 g)

Calculate

(i) the number of moles of zinc blende which was used.

$$\text{No of moles of zinc blende} = \frac{97 \times 10^6}{65 + 32}$$
$$= 1 \times 10^6 \text{ mol [1]}$$

(ii) the number of moles of zinc oxide which was produced from the reaction between zinc blende and oxygen.

If you were unable to complete **(a)**, you may assume that 1 mole of zinc blende produces 2 moles of zinc oxide.
Comparing mole ratios, number of moles of zinc oxide = 1×10^6 mol [1]

(iii) the mass of carbon which was required to completely react with the zinc oxide.

If you were unable to complete **(a)**, you may assume that zinc oxide and carbon react in a 2:1 ratio.
Mass of carbon = $1 \times 10^6 \times 12$
$= 1.2 \times 10^7$ g OR 12 tonnes [1]

(iv) the mass of zinc which was extracted at the end of the reaction.

If you were unable to complete **(a)**, you may assume that 2 moles of zinc oxide produces 1 mole of zinc.
Mass of zinc extracted = $1 \times 10^6 \times 65$
$= 6.5 \times 10^7$ g or 65 tonnes [1]

B5 A white solid is known to be a mixture of zinc carbonate and sodium carbonate.

(a) To find the percentage by mass of zinc carbonate in the mixture, 5.0 g of the mixture was heated strongly until no further changes were observed.

When zinc carbonate is heated strongly, it decomposes according to the equation below.

$$ZnCO_3 \rightarrow ZnO + CO_2$$

However, when sodium carbonate is heated strongly, it does not decompose.

When the heating had completed, 0.48 dm^3 of carbon dioxide gas had been produced.

Calculate

(i) the number of moles of carbon dioxide which was produced from heating the mixture.

$$\text{No of moles of carbon dioxide} = \frac{0.48}{24}$$
$$= 0.02 \text{ mol [1]}$$

(ii) the mass of zinc carbonate present in the mixture.

Mass of zinc carbonate present = 0.02 X (65 + 12 + 16 X 3)
= 2.5 g [1]

(iii) the percentage by mass of zinc carbonate in the mixture.

$$\text{Percentage by mass} = \frac{2.5}{5.0} \times 100\%$$
$$= 50\% \text{ [1]}$$

(b) 1.25 g of solid zinc carbonate was reacted with excess dilute nitric acid to produce aqueous zinc nitrate, carbon dioxide and water.

(i) Write the ionic equation for the reaction of solid zinc carbonate with dilute nitric acid.

$ZnCO_3$ (s) + $2H^+$ (aq) $\rightarrow$ Zn^{2+} (aq) + CO_2 (g) + H_2O (l)

[1] – correct chemical species
[1] – correct balancing

(ii) A 100 cm^3 gas syringe was used to collect the carbon dioxide produced in this reaction.

By calculating the volume of carbon dioxide produced in this reaction, show that the volume of the syringe would be insufficient to contain the carbon dioxide produced.

(1 dm^3 = 1000 cm^3)

$$\text{No of moles of zinc carbonate} = \frac{1.25}{65+12+16\times3}$$
$$= 0.01 \text{ mol [1]}$$

No of moles of carbon dioxide = 0.01 mol [no marks]

Volume of carbon dioxide = 0.01 X 24
= 0.24 dm^3 or 240 cm^3 [1]

Therefore, the volume of the syringe is insufficient. [no marks]

END OF PAPER