Anglo-Chinese School
(Independent)

Year 3 Integrated Programme
Final Examination 2020

CHEMISTRY
PAPER 1
Wednesday 30th September 2020 1 hour

Additional material:
OTAS answer sheet

INSTRUCTIONS TO CANDIDATES
Do not open this booklet until you are told to do so.
Shade your Candidate Number on the OTAS answer sheet in the spaces provided.

Answer **all** questions. 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 OTAS answer sheet.

INFORMATION FOR CANDIDATES
There are **forty** questions in this paper, carrying a total of **40 marks**.

A copy of the Periodic Table is printed on page **2**.

Electronic calculators may be used.

This booklet consists of 13 printed pages, including this cover page.

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1 Which substance would undergo two changes of state when heated from -20°C to 65°C?

substance	melting point / °C	boiling point / °C
A.	-18	60
B.	-24	18
C.	-115	56
D.	42	108

2 Which of the following statements about a pure substance during boiling is correct?

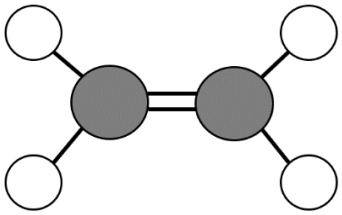
A. The distance between the particles increases.

B. The kinetic energy of the particles increases.

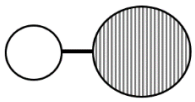
C. The size of the particles increases.

D. The strength of the forces of attraction between the particles increases.

3 The models and formulae for some molecules are shown below.



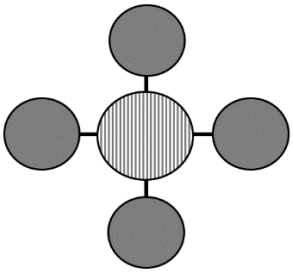
R_2S_4



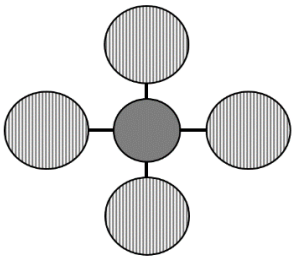
ST

Which is the correct model for a molecule of a compound formed between **R** and **T**?

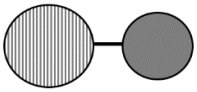
A.



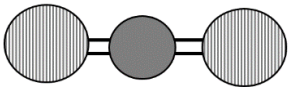
B.



C.



D.



4 What is the total number of atoms in 36.04 g of water molecules?

A. 3.01×10^{23} atoms

B. 9.03×10^{23} atoms

C. 12.04×10^{23} atoms

D. 36.12×10^{23} atoms

5 Which of the following contains the greatest number of ions?

A. 10.0 cm^3 of 2.5 mol dm^{-3} of K_2CO_3 solution

B. 20.0 cm^3 of 2.0 mol dm^{-3} of KNO_3 solution

C. 30.0 cm^3 of 1.5 mol dm^{-3} of K_2SO_4 solution

D. 40.0 cm^3 of 1.0 mol dm^{-3} of K_3PO_4 solution

6 200 cm^3 of water is added to 50.0 cm^3 of 4 g dm^{-3} aqueous ammonium nitrate, NH_4NO_3.

What is the new molar concentration of the ammonium nitrate solution?

A. 0.0100 mol dm^{-3}

B. 0.0125 mol dm^{-3}

C. 1.28 mol dm^{-3}

D. 1.60 mol dm^{-3}

7 15 cm^3 of ethane burns in 35 cm^3 of oxygen to form carbon dioxide and water.

$$2C_2H_6\ (g) + 7O_2\ (g) \longrightarrow 4CO_2\ (g) + 6H_2O\ (l)$$

What is the total volume of gases remaining after the reaction?

All gas volumes are measured at room temperature and pressure.

A. 20 cm^3

B. 25 cm^3

C. 30 cm^3

D. 100 cm^3

8 0.175 g of a dibasic acid requires 25.0 cm^3 of 0.200 mol dm^{-3} of aqueous sodium hydroxide to react completely.

What is the molar mass of the acid?

A. 22.0 g mol^{-1}

B. 35.0 g mol^{-1}

C. 44.0 g mol^{-1}

D. 70.0 g mol^{-1}

9 Dinitrogen tetraoxide, N_2O_4, is a liquid at room temperature and pressure.

The following statements were made about dinitrogen tetraoxide.

I. It has a molar volume of 24 dm^3 at room temperature and pressure.
II. The empirical formula is NO_2.
III. The percentage mass of nitrogen in the molecule is 30.4%.

Which statements are correct?

A. I and II

B. I and III

C. II and III

D. I, II and III

10 When nuclear reactions take place, the elements produced are different from the elements that reacted. Nuclear equations, such as the one below, are used to represent the changes that occur.

In the equation, the nucleon (mass) number total is constant at 31 and the proton number total is constant at 15 where $^{1}_{0}n$ is one neutron.

$$^{27}_{13}Al + {}^{4}_{2}He \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$$

In another nuclear reaction, as seen below, nitrogen is reacted with a neutron, $^{1}_{0}n$. An isotope, **J**, is formed as well as a hydrogen atom.

$$^{14}_{7}N + {}^{1}_{0}n \longrightarrow \mathbf{J} + {}^{1}_{1}H$$

What is isotope **J**?

A. ^{12}C

B. ^{14}C

C. ^{14}N

D. ^{15}N

11 Four electronic configurations are shown below. Three of these belong to atoms of lithium, chlorine and calcium.

Which electronic configuration belongs to an atom of another element?

A. $1s^2 2s^1$

B. $1s^2 2s^2 2p^3$

C. $1s^2 2s^2 2p^6 3s^2 3p^5$

D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

12 What is the condensed electronic configuration for the sulfur atom in its ground state?

A. [Mg] $3p^4$

B. [He] $2s^2 2p^6 3s^2 3p^4$

C. [Ne] $3s^2 3p^4$

D. [Ne] $3p^6$

13 Which statement about the ions $^{63}Cu^{2+}$ and $^{65}Cu^{+}$ is correct?

A. Both ions have the same number of protons.

B. Both ions have the same number of electrons.

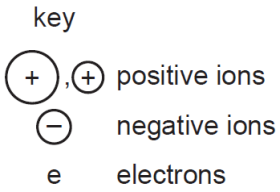
C. Both ions have the same number of neutrons.

D. Both ions have the same ionic radius.

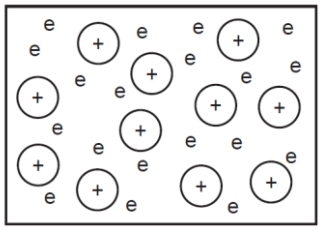
14 Element **X** has a giant metallic structure. Which of the following shows its properties?

	electrical conductivity		**physical state of the oxide of X at r.t.p.**
	in the solid state	**in the liquid state**	
A.	✓	✓	solid
B.	✓	✓	liquid
C.	✗	✓	gas
D.	✗	✗	solid

15 Which of the following structures depicts the arrangement of particles in a pure solid metal?



A.



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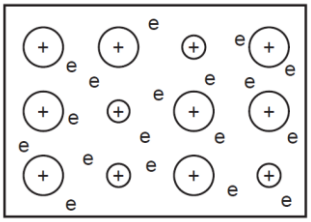
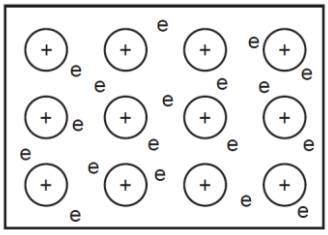
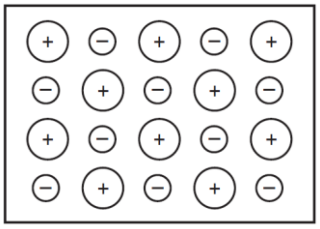


C.

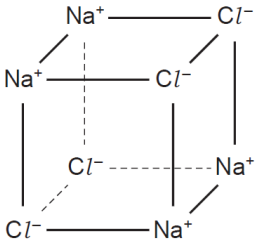


D.

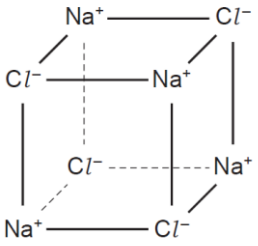


16 Which diagram correctly shows the arrangement of ions in solid sodium chloride?

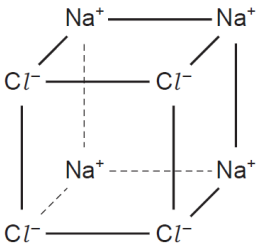
A.



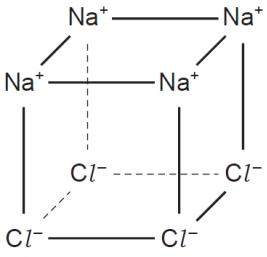
B.



C.



D.



17 What happens when potassium bromide melts?

A. Covalent bonds in the giant lattice are broken.

B. Electrons are released from atoms.

C. Electrostatic forces of attraction between ions are overcome.

D. Molecules are separated into ions.

18 Which pair will conduct electricity because they both contain mobile ions?

A. aqueous copper(II) sulfate and molten sodium chloride

B. solid copper metal and aqueous copper(II) sulfate

C. solid copper metal and solid graphite

D. solid graphite and molten sodium chloride

19 The melting point of calcium oxide is much higher than the melting point of sodium oxide. Which statement explains this?

A. Calcium atom has a higher first ionization energy than sodium atom.

B. Calcium ion has a bigger charge than sodium ion.

C. Calcium ion has greater shielding effect than sodium ion.

D. Calcium ion has lesser protons than sodium ion.

20 Which of the following statements provides the best explanation for the solubility of ionic compounds in water?

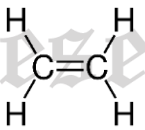
A. Like dissolves like.

B. The positive and negative ions are attracted to different regions of the polar water.

C. There are delocalised particles in the aqueous state.

D. There are positive and negative ions present in the substance.

21 Ethene, C_2H_4, has very low melting and boiling points.



Based on the structure above, this is because of

A. weak covalent bonding between atoms in the molecules.

B. weak dipole-dipole interactions between molecules.

C. weak hydrogen bonding between molecules.

D. weak London dispersion forces between molecules.

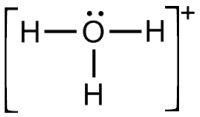
22 Each of the four molecules below is isolated in the gaseous state.

Which species has an atom that does not obey the octet rule?

A. BF_3 B. CO_2

C. Cl_2 D. NH_3

23 The Lewis structure for H_3O^+ is shown below.



What is the shape of H_3O^+?

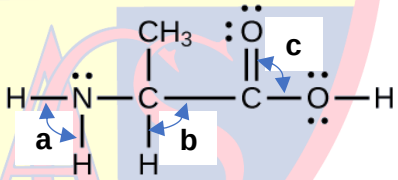
A. Bent

B. Tetrahedral

C. Trigonal planar

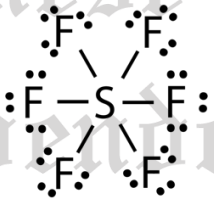
D. Trigonal pyramidal

24 Based on the VSEPR theory, which bond angles correctly correspond to the diagram below?



	a	b	c
A.	90°	90°	120°
B.	109.5°	90°	<120°
C.	<109.5°	109.5°	120°
D.	109.5°	109.5°	<120°

25 SF_6 molecule is shown as below.



Which of the following statements are correct about the molecule above?

I. The compound would be named sulfur hexafluoride.
II. The octet rule is obeyed by all atoms in this Lewis structure.
III. The central sulfur atom shows an expanded valence-shell octet observed in some compounds containing Period 3 elements.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26 Which statement about group 1 elements is correct?

A. The density generally decreases down the group.

B. The melting point generally increases down the group.

C. The oxidizing power increases down the group.

D. The reactivity increases down the group.

27 Across a period, the elements show a trend from being metallic to non-metallic. Which of the following best explains this trend?

A. An increase in the nuclear charge.

B. An increase in the number of valence electrons.

C. An increase in the distance between the nucleus and the valence electrons.

D. An increase in the shielding effect of the inner electrons.

28 Which equation shows the second ionization energy of element **M**?

A. $M(g) \longrightarrow M^{2+}(g) + 2e^-$

B. $M^+(g) \longrightarrow M^{2+}(g) + e^-$

C. $M(g) + 2e^- \longrightarrow M^{2-}(g)$

D. $M^-(g) + e^- \longrightarrow M^{2-}(g)$

29 Which of the following shows the correct comparison of the radius of the two particles?

A. $Ca^{2+} < Mg^{2+}$

B. $Na < Na^+$

C. $S^{2-} < Cl^-$

D. $Si < Al$

30 What is the ionic equation for the reaction between sodium carbonate solution and dilute sulfuric acid?

A. $2Na^+(aq) + SO_4^{2-}(aq) \longrightarrow Na_2SO_4(s)$

B. $Na_2CO_3(aq) + 2H^+(aq) \longrightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$

C. $CO_3^{2-}(aq) + 2H^+(aq) \longrightarrow CO_2(g) + H_2O(l)$

D. $Na_2CO_3(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H^+(aq) + CO_3^{2-}(aq)$

31 Assuming that the concentration of hydrochloric acid, HCl and ethanoic acid, CH_3COOH is the same, which statement about these two acids is correct?

A. The pH value of CH_3COOH is higher as it contains a higher concentration of hydrogen ions.

B. The pH value of CH_3COOH is lower as it dissociates partially in water.

C. CH_3COOH reacts with Mg faster than HCl as it contains a higher concentration of hydrogen ions.

D. CH_3COOH reacts with Mg slower than HCl as it dissociates partially in water.

32 Which statement about the reaction between aqueous ammonium carbonate and sodium hydroxide solution is correct?

A. An acidic gas is produced.

B. An alkaline gas is produced.

C. A neutral gas is produced.

D. No gas is produced.

33 Hydrazine has the formula H_2NNH_2. It has similar properties to ammonia.

Which property will hydrazine have?

A. It can conduct electricity only in solid state.

B. It dissociates in water to produce hydrogen ions.

C. It is a solid at room temperature.

D. It reacts with an acid to form a salt.

34 The formulae of some oxides are shown below.

MgO PbO ZnO CO SO_2

How many oxide(s) listed above can react with aqueous sodium hydroxide?

A. 1 B. 2

C. 3 D. 4

35 An unknown pH indicator is added to separate samples of hydrochloric acid, vinegar, and aqueous ammonia of the same concentration. The resulting colour of the indicator are shown below.

hydrochloric acid	vinegar	aqueous ammonia
red	purple	purple

The indicator is observed to change colour in the following pH:

pH range	colour
1 - 4	red
4 - 13	purple

Which statement about the pH indicator is **not** correct?

A. It can distinguish a strong acid from a strong alkali.

B. It can distinguish a strong acid from a weak alkali.

C. It can distinguish a weak acid from a strong acid.

D. It can distinguish a weak acid from a weak alkali.

36 Chlorine can react with sodium hydroxide as shown. The resulting mixture can be used as bleach.

$$Cl_2\,(aq) + 2NaOH\,(aq) \longrightarrow NaCl\,(aq) + NaClO\,(aq) + H_2O\,(l)$$

Which statement about this reaction is correct?

A. Chlorine is both oxidised and reduced.

B. Chlorine is neither oxidised nor reduced.

C. Chlorine is oxidised only.

D. Chlorine is reduced only.

37 Which of the following would be correct for the reaction below?

$$K_2Cr_2O_7\,(aq) + 3SO_2\,(g) + H_2SO_4\,(aq) \longrightarrow K_2SO_4\,(aq) + Cr_2(SO_4)_3\,(aq) + H_2O\,(l)$$

I. Sulfur dioxide is the oxidizing agent.

II. The solution turns from orange to green.

III. The potassium ions are spectator ions.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

38 One way of recovering tin from old printed circuit boards is to dissolve it in a mixture of concentrated hydrochloric acid and concentrated nitric acid. The tin dissolves because it reacts with the mixture of these concentrated acids.

$$Sn + 4HCl + 2HNO_3 \longrightarrow SnCl_4 + NO_2 + NO + 3H_2O$$

Which statements about this reaction are correct?

I. Nitrogen is present in three different oxidation states in the reactant and products.
II. The oxidation state of tin increases from 0 to +4.
III. The oxidation state of chlorine remains the same.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

39 When acidified potassium manganate(VII) is added to an aqueous colourless solution of compound **X**, the colour of acidified potassium manganate(VII) changes …**1**…. This colour change shows that **X** is …**2**….

Which words correctly fill in the blanks **1** and **2**?

	1	**2**
A.	from colourless to purple	oxidized
B.	from colourless to purple	reduced
C.	from purple to colourless	oxidized
D.	from purple to colourless	reduced

40 The equation for the reaction between iron(II) sulfate and bromine is shown.

$$6FeSO_4 + 3Br_2 \longrightarrow 2Fe_2(SO_4)_3 + 2FeBr_3$$

Which row identifies the oxidizing agent and the reducing agent?

	Oxidizing agent	***Reducing agent***
A.	Br_2	$FeSO_4$
B.	$FeSO_4$	Br_2
C.	$FeBr_3$	$Fe_2(SO_4)_3$
D.	$Fe_2(SO_4)_3$	$FeBr_3$

END OF PAPER

Candidate Number

Anglo-Chinese School (Independent)

Year 3 Integrated Programme
Final Examination 2020

CHEMISTRY
PAPER 2

Wednesday 30th September 2020 1 hr 45 min

INSTRUCTIONS TO CANDIDATES
Do not open this booklet until you are told to do so.

Write your Candidate Number in the space at the top of this page.

Answer **all** questions in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES
This paper carries a total of **80 marks**.

A copy of the Periodic Table is printed on page **18**.

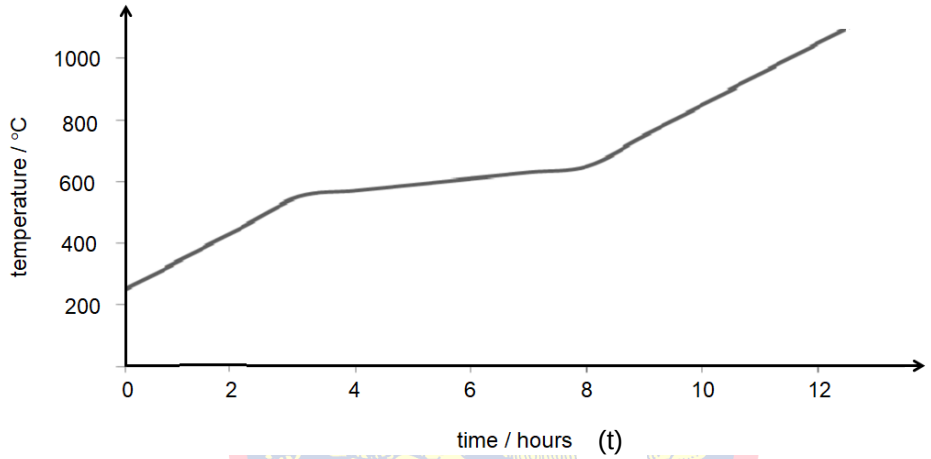
Electronic calculators may be used.

Marks will be deducted for omission of statements, incorrect number of significant figures and incorrect or missing units in calculation questions.

For Examiners' Use		
Question 1		/ 9
Question 2		/ 8
Question 3		/ 5
Question 4		/ 5
Question 5		/ 11
Question 6		/ 9
Question 7		/ 8
Question 8		/ 7
Question 9		/ 6
Question 10		/ 5
Question 11		/ 7
Deductions	statements	
	s.f. / d.p.	
	units	
Total		**/ 80**

This paper consists of 18 printed pages, including this cover page.

1 The graph shows the heating curve of an impure sample of solid calcium chloride.



(a) **(i)** What is the effect of the impurity on the melting temperatures of calcium chloride? [1]

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(ii) Explain, in terms of bonding and structure, why calcium chloride has a high melting point. [3]

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(b) Describe the arrangement and motion of the particles at **t**=0. [2]

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(c) Excess hydrochloric acid was added to 40.0 g of impure calcium carbonate to produce calcium chloride, carbon dioxide, and water. 14.8 g of carbon dioxide was produced. The mole ratio of calcium carbonate reacted to carbon dioxide produced is 1:1. [3]

Calculate the percentage purity of calcium carbonate. Give your answer correct to 3 significant figures.

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2 An unknown group 2 element **X** is present in the form of a carbonate, **X**CO_3. An investigation was carried out to identify this element where 5.68 g of **X**CO_3 was added to 25.0 cm^3 of 2.00 mol dm^{-3} sulfuric acid. The mixture was stirred continuously until effervescence stopped.

The unreacted sulfuric acid required 23.00 cm^3 of 1.00 mol dm^{-3} aqueous sodium hydroxide for complete neutralisation.

(a) **(i)** Calculate the number of moles of sulfuric acid that reacted with aqueous sodium hydroxide. Give your answer correct to 3 significant figures. [2]

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(ii) Hence, calculate the number of moles of sulfuric acid that reacted with **X**CO_3. Give your answer correct to 3 significant figures. [2]

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(iii) Construct a chemical equation for the reaction between **X**CO_3 and sulfuric acid. [1]

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(iv) State the number of moles of **X**CO_3 that reacted. Give your answer correct to 3 significant figures. [1]

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(v) Calculate the molar mass of **X**CO_3 and hence identify the element **X**. Give your answer correct to 2 decimal places. [2]

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Element **X** is .....

3 Cyanogen, a highly toxic gas, is composed of 46.2% carbon and 53.8% nitrogen by mass. At room temperature and pressure, 1.30 g of cyanogen occupies 0.600 dm^3.

(a) Calculate the molar mass, in g mol^{-1}, of cyanogen. Give your answer correct to 1 decimal place. [2]

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(b) Determine the empirical formula and molecular formula of cyanogen. [3]

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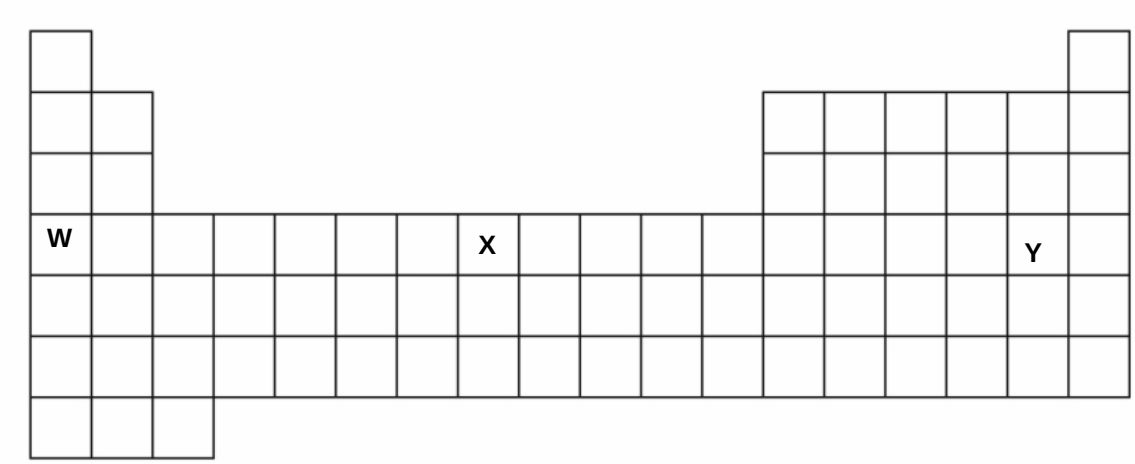
Empirical formula .....

Molecular formula .....

4 The positions of the element **W**, **X** and **Y** are shown in the outline of part of the Periodic Table.



(a) State one similarity and one difference in the properties between elements **W** and **X**. [2]

Similarity: .....

.....

Difference: .....

.....

(b) Element **Y** and **Z** are in the same group.

(i) When an aqueous solution of Y_2 was added to an aqueous solution of Na**Z**, the solution turned darker and some black precipitate was also observed. [2]

Explain the observation.

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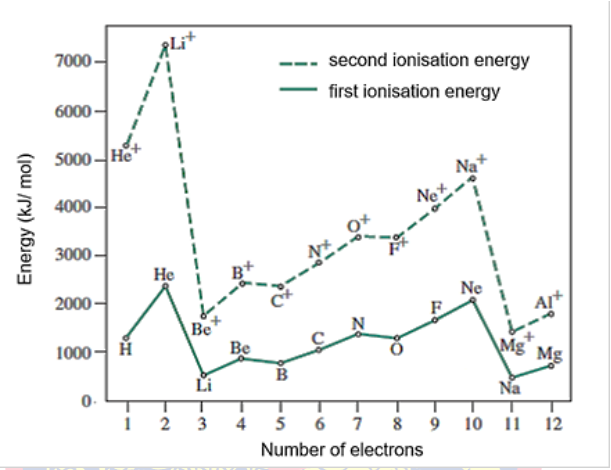
(ii) On the Periodic Table above, mark the position of element **Z** with the letter '**Z**'. [1]

5 The first and second ionization energies (I.E.) of different species are shown below.



(a) **(i)** Complete the 'electron-in-box' orbital diagrams for the nitrogen and oxygen atoms. State the type of subshell below the boxes. [3]

N atom: ⇅ ⇅ ☐ ☐ ☐ ☐ ☐ ☐

1s 2s …… …… ……

O atom: ⇅ ⇅ ☐ ☐ ☐ ☐ ☐ ☐

1s 2s …… …… ……

(ii) Explain why the first I.E. of oxygen is lower than that of nitrogen. [2]

……

(b) **(i)** Complete the full electronic configuration for the Na^+ and the Mg^+ ions in their ground state. [2]

Na^+ ion : $1s^2\ 2s^2$ ……

Mg^+ ion : $1s^2\ 2s^2$ ……

(ii) Explain why the second I.E. of sodium is greater than that of magnesium. [2]

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(c) Contrast and explain the difference in the radius between an O^+ ion and an O atom. [2]

……

6 Group 15 elements react with hydrogen to form hydrides. The type of bond formed can be determined by the difference in electronegativity.

electronegativity difference	type of bond
0.0 – 0.2	non-polar covalent
0.3 – 1.4	polar covalent
> 1.5	ionic

(a) Define the term electronegativity. [2]

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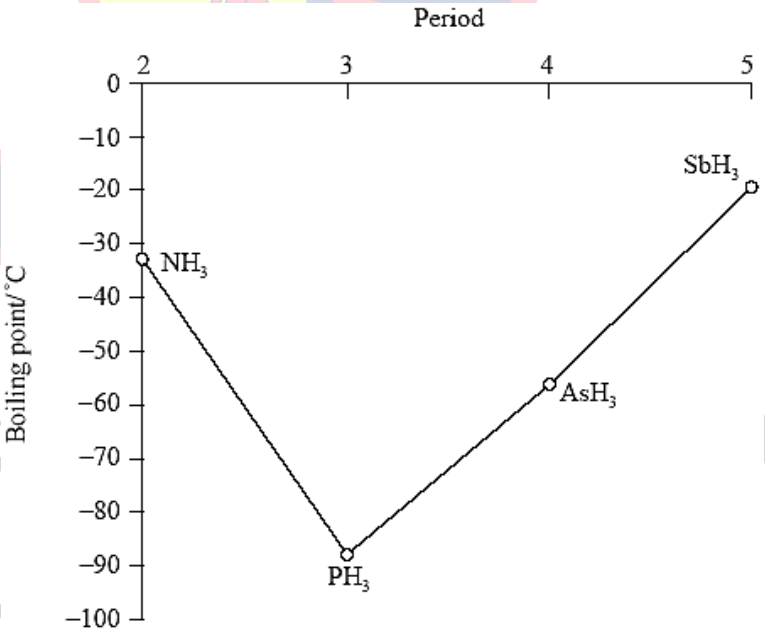
(b) The boiling points of some hydrides are shown in the graph below.



(i) State and explain the boiling point trend seen in the graph above from PH_3 to SbH_3. [2]

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(ii) Explain why NH_3 is an exception. [1]

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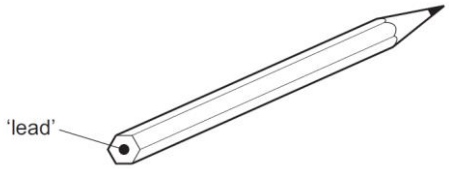
(c) Using the VSEPR theory, draw the Lewis structure of the NH_3 molecule and state its bond angle and shape. [4]

Bond angle .....

Shape .....

7 The 'lead' in a pencil is made of a mixture of graphite and clay.



(a) When the percentage of graphite is increased, the pencil 'lead' slides across the paper more easily. Explain this observation using the structure and bonding present in graphite. [2]

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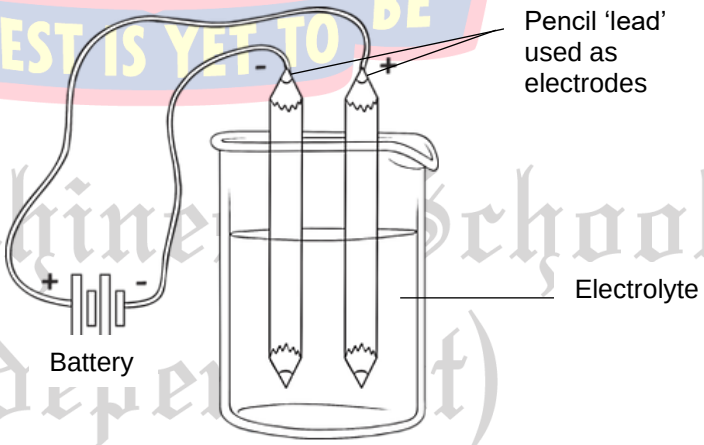
(b) Electrolysis is a process where electricity is used to break down or decompose a substance. Pencil 'lead' can be used as an electrode for electrolysis. The diagram below shows how two pencils are used in this process.



Explain why pencil 'leads' can be used in the above set-up successfully. [2]

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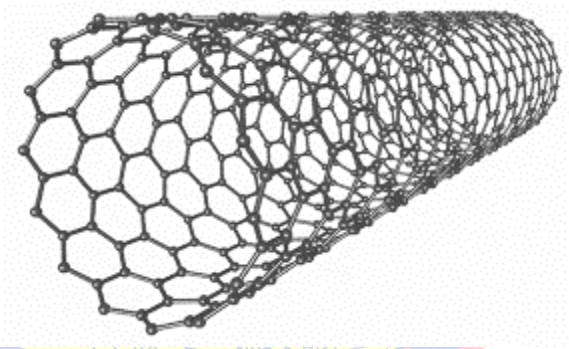
(c) Graphite is an allotrope of carbon. Carbon nanotubes are also allotropes of carbon as shown below. [2]



Based on the structure above, would you expect its melting point to be high or low? Explain.

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(d) Tin (Sn), is another element in group 14 that has different allotropic forms.

α-Sn (grey tin) is the stable form below 13^{o}C and has a diamond-like structure.

β-Sn (white tin) is metallic and has a close-packed lattice.

(i) Deduce which allotrope of tin is malleable. [1]

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(ii) Based on the information above, suggest a use for the allotrope in **(d)(i)**. [1]

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8 Group 1 metals, also known as Alkali Metals, are very reactive metals.

(a) Write a balanced chemical equation, with state symbols, for the reaction between lithium and water. [2]

.....

(b) Potassium is below lithium in Group 1. Its hydroxide is typically reacted with iodine to prepare potassium iodide as shown below.

$$3I_2 + 6KOH \rightarrow 5KI + KIO_3 + 3H_2O$$

(i) The completion of the reaction can be determined by a colour change in the solution. State the expected observation in the reaction mixture. [1]

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(ii) Potassium iodide is commonly used as a test reagent. State whether it is expected to be an oxidising agent or a reducing agent. [1]

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(c) Sodium is between lithium and potassium in the group.

(i) State the order of reactivity for the three metals starting from the least reactive to the most reactive. [1]

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(ii) State whether Alkali metals have reducing or oxidizing power and determine which amongst lithium, sodium, and potassium would be the strongest one. [2]

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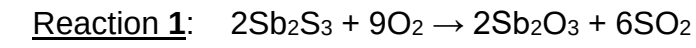
9 The element antimony, Sb, is usually found in nature as its sulfide ore, stibnite, having the formula Sb_2S_3. This ore was used two thousand years ago by ancient Egyptian women as a cosmetic to darken their eyes and eyelashes.

(a) One method of extracting antimony from its sulfide ore is to roast stibnite in air. This forms antimony oxide and sulfur dioxide:



Reaction **1**: $2Sb_2S_3 + 9O_2 \rightarrow 2Sb_2O_3 + 6SO_2$

The antimony oxide then undergoes the following reaction with carbon:

Reaction **2**: $2\ Sb_2O_3 + 3C \rightarrow 4Sb + 3CO_2$

(i) Explain, using oxidation states, if the sulfur in Sb_2S_3 is reduced or oxidised in reaction **1**. [3]

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(ii) Determine whether carbon behaves as an oxidising agent or a reducing agent in reaction **2**. [1]

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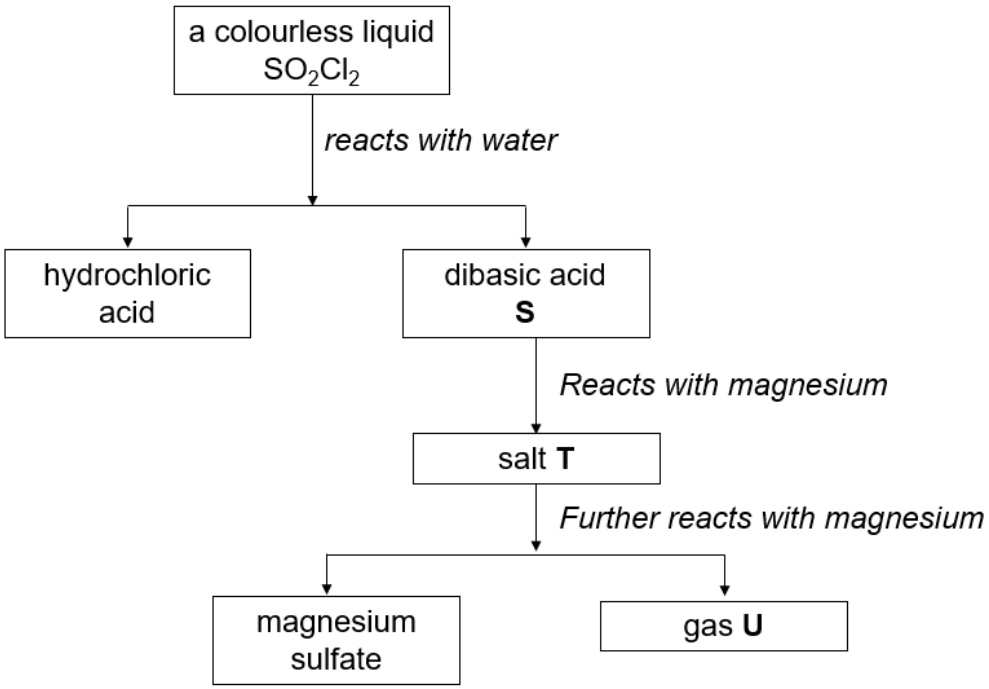
(b) Antimony reacts with concentrated nitric acid to form another oxide. [2]

$4Sb + 20HNO_3 \rightarrow Sb_4O_{10} + 20NO_2 + 10H_2O$

Determine the oxidation state of antimony in its oxides and fill in the table below.

oxide	oxidation state of antimony
Sb_2O_3	
Sb_4O_{10}	

10 Sulfuryl chloride, SO_2Cl_2 is a colourless liquid with a pungent smell. It reacts with water to form hydrochloric acid and a dibasic acid.



(a) Construct a chemical equation, including state symbols, for the reaction between sulfuryl chloride and water. [2]

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(b) Give the name of salt **T** produced. [1]

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(c) Identify gas **U** and describe a test to confirm the gas. [2]

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11 **(a)** Both hydrochloric acid and ethanoic acid, CH_3COOH are monobasic acids. Hydrochloric acid is a strong acid while ethanoic acid is a weak acid.

(i) With the aid of a chemical equation, explain why ethanoic acid is a weak monobasic acid. [3]

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(ii) Ethanoic acid has a degree of dissociation of 1%. [2]

Calculate the pH of 0.200 mol dm^{-3} ethanoic acid. Give your answer correct to 1 decimal place.

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(b) Sodium ethanoate can be prepared by reacting sodium metal with ethanoic acid. Sodium ethanoate is soluble in water as shown below: [2]

$$CH_3COONa\,(aq) \rightarrow CH_3COO^-\,(aq) + Na^+\,(aq)$$

With the help of a reversible equation, state whether sodium ethanoate is a basic or acidic salt.

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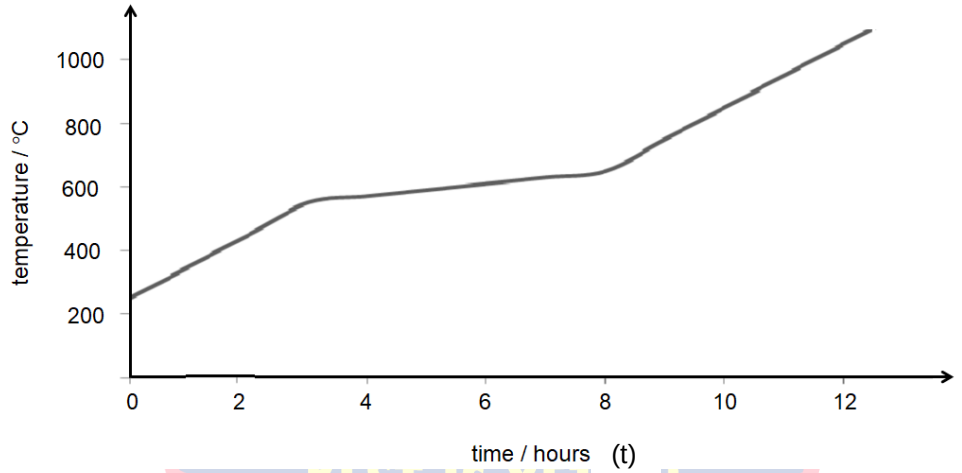
Anglo-Chinese School (Independent) Year 3 IP Chemistry Final Exam 2020 Answers

Paper 1

1	2	3	4	5	6	7	8	9	10
A	A	B	D	D	A	B	D	C	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	C	A	A	C	B	C	A	B	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	A	D	C	B	D	A	B	D	C
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
D	B	D	C	D	A	C	D	C	A

Paper 2

1 The graph shows the heating curve of an impure sample of solid calcium chloride.



(a) **(i)** What is the effect of the impurity on the melting temperature of calcium chloride? [1]

EITHER decreases the melting point of pure calcium chloride
OR melting occurs over a range of temperatures
Accept:
- Melting temperature **increases with time**
- The temperature **continues to increases** as it melts
- Melting temperature is **not constant.**

(ii) Explain, in terms of bonding and structure, why calcium chloride has a high melting point. [3]

It has a **giant ionic structure** (accept: giant crystal lattice; giant lattice structure)[1] held together by **strong electrostatic attraction between oppositely charged ions**. (accept: strong ionic bond between ions) [1] Hence, a **lot of energy is required to overcome** (accept: more energy required) the strong electrostatic attraction between the oppositely charged ions.[1]

(b) Describe the arrangement and motion of the particles at **t**=0. [2]

Particles are closely packed in orderly manner for pure sample or disorderly manner for impure sample [1]. Particles vibrate about their fixed position [1].

(c) Excess hydrochloric acid was added to 40.0 g of impure calcium carbonate to produce calcium carbonate, carbon dioxide, and water. 14.8 g of carbon dioxide was produced. The mole ratio of calcium carbonate reacted to carbon dioxide produced is 1:1. [3]

Calculate the percentage purity of calcium carbonate. Give your answer correct to 3 significant figures.

No. of moles of CO_2 = 14.8 / 44.01 = 0.336287 mol [1]
No of moles of $CaCO_3$ = 0.336287 mol
Mass of $CaCO_3$ = 0.336297 X 100.09 = 33.65899 g [1]
% purity = 33.65899 / 40 X 100% = 84.1% [1]

2 An unknown group 2 element **X** is present in the form of a carbonate, **X**CO_3.

An investigation was carried out to identify this element where 5.68 g of **X**CO_3 was added to 25.0 cm^3 of 2.00 mol dm^{-3} sulfuric acid. The mixture was stirred continuously until effervescence stopped.

The acid remaining in the mixture requires 23.00 cm^3 of 1.00 mol dm^{-3} aqueous sodium hydroxide for complete neutralisation.

(a) **(i)** Calculate the number of moles of sulfuric acid that reacted with aqueous sodium hydroxide. Give your answer correct to 3 significant figures. *[2]*

No. of moles of NaOH = 0.0230 X 1.00 = 0.0230 mol [1]
No. of moles of H_2SO_4 = 0.0230 mol / 2 = 0.0115 mol [1]

(ii) Hence, calculate the number of moles of sulfuric acid that reacted with **X**CO_3. Give your answer correct to 3 significant figures. *[2]*

Total number of moles of H_2SO_4 = 0.025 X 2 = 0.0500; [1]
No. of moles of H_2SO_4 that reacted with XCO_3 = 0.0500 – 0.0115 = 0.0385 mol; [1]\

(iii) Construct a chemical equation for the reaction between **X**CO_3 and sulfuric acid. *[1]*

$XCO_3 + H_2SO_4 \rightarrow XSO_4 + CO_2 + H_2O$

(iv) State the number of moles of **X**CO_3 that reacted. Give your answer correct to 3 significant figures. *[1]*

No. of moles of XCO_3 = 0.0385 mol

(v) Calculate the molar mass of **X**CO_3 and hence identify element **X**. Give your answer correct to 2 decimal places. *[2]*

Molar mass of XCO_3 = 5.68 / 0.0385 = 147.53 g mol^{-1} ; [1]
Molar mass of X = 147.53 – 12.01 – 3(16.00) = 87.53
Element **X** is strontium or Sr.

3 Cyanogen, a highly toxic gas, is composed of 46.2% carbon and 53.8% nitrogen by mass. At room temperature and pressure, 1.30 g of cyanogen occupies 0.600 dm^3.

(a) Calculate the molar mass of cyanogen. *[2]*

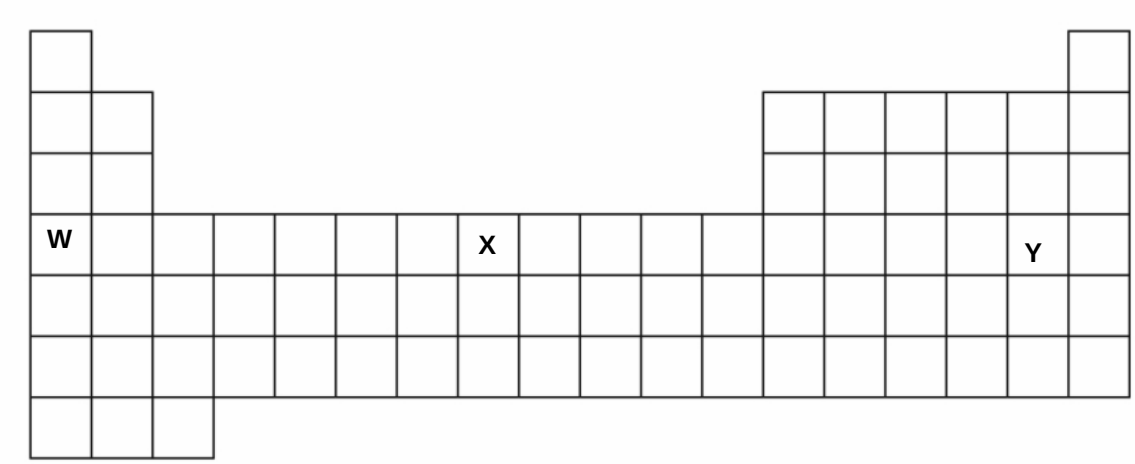
No. of moles of cyanogen = 0.600 / 24.0 = 0.0250 mol [1]
Molar mass of cyanogen = 52.0 g mol^{-1} [1]

(b) Determine the empirical formula and molecular formula of cyanogen. *[3]*

	C	N	
Mass/g	46.2	53.8	
No. of moles	3.8468	3.8401	[1]
Simplest ratio	1	1	

Empirical formula: CN [1]
(12.01 + 14.01)n = 52.0
n = 2 (nearest whole number)
Molecular formula: C_2N_2 [1]

4 The positions of the element **W**, **X** and **Y** are shown in the outline of part of the Periodic Table.



(a) State one similarity and one difference in the properties between elements **W** and **X**. *[2]*

Similarity: Both are good conductors of heat/ good conductors of electricity/ react with acids to form salts and hydrogen; [1]
(Accept: Malleable/ ductile/ form cations/ reacts with **non-metal** to form (ionic) compound/ loses electron to form cations.)
Difference: X has a higher melting point/ higher density/ forms coloured compound/ can have variable oxidation states (must show comparison); [1]
(Accept: Compare reactivity/ reaction/ electropositive/ electronegative)

(b) Element **Y** and **Z** are in the same group.

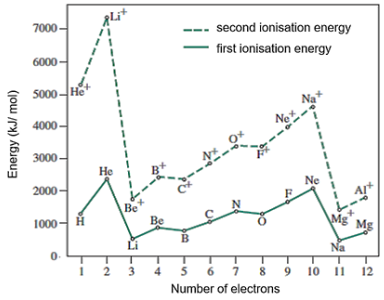
(i) When an aqueous solution of Y_2 was added to an aqueous solution of Na**Z**, the solution turned darker and some black precipitate was observed. *[2]*

Explain the observation.

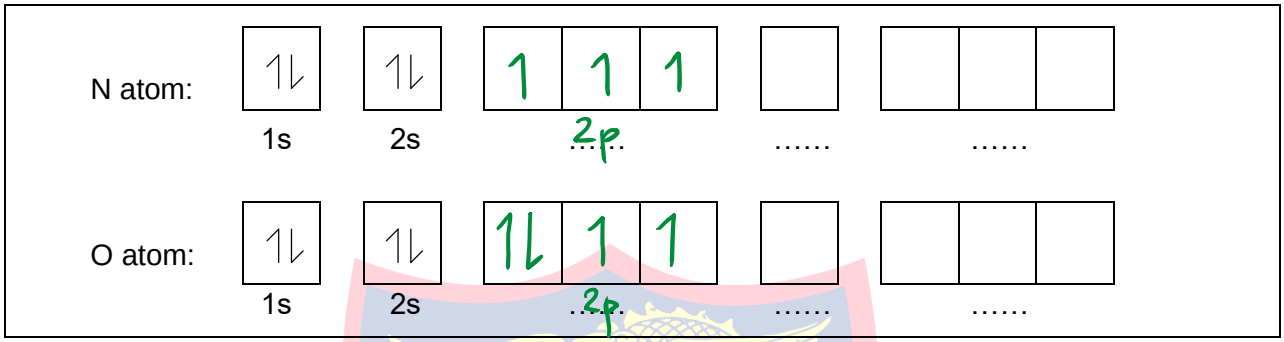
Y_2 is **more reactive** than Z; [1] (accept: Y is more oxidising than Z)
thus it **displaces** Z from its solution; [1] (accept: change in oxidation state)

(ii) On the Periodic Table, mark and label the position of element **Z** with a letter '**Z**'. (accept any position below Y in the same group) *[1]*

5 ~~The first and second ionization energies (I.E.) of different species are shown below.~~



(a) **(i)** Complete the 'electron-in-box' orbital diagrams for the nitrogen and oxygen atoms. State the type of subshell below the boxes. [3]



~~**(ii)** Explain why the first I.E. of oxygen is lower than that of nitrogen.~~ ~~[2]~~

~~In oxygen atom, less energy is required to remove the paired 2p electrons as it experience **inter-electron repulsion** arising from **2 electrons occupying a 2p orbital**; [1]~~
~~In nitrogen atom, it has **unpaired 2p electrons** so there is no inter-electronic repulsion in the 2p orbitals; [1] (accept: singly occupied)~~

(b) **(i)** Complete the full electronic configuration for the Na^+ and the Mg^+ ions in their ground state. [2]

Na^+ ion : $1s^2\ 2s^2\ 2p^6$
Mg^+ ion : $1s^2\ 2s^2\ 2p^6\ 3s^1$

~~**(ii)** Explain why the second I.E. of sodium is greater than that of magnesium.~~ ~~[2]~~

~~Na^+ has **2 quantum shells/electron shells** while Mg^+ **has 3 quantum shells/electron shells** or Na^+ has **one electron shell** fewer than Mg^+ or The electron is removed from **2p subshell** for Na^+ and **3s subshell** for Mg^+. OWTTE [1]~~
~~The second electron is removed from the **shell which is closer to the nucleus / lower energy level** for Na^+ or **less shielding effect for Na$^+$** as compared to Mg^+ and thus more energy is required to remove the second electron. OWTTE [1]~~

~~**(c)** Contrast and explain the difference in the radius between an O^+ ion and an O atom.~~ ~~[2]~~

~~O^+ ion is **smaller** than O atom; [1]~~
~~In O^+ ion, the valence electrons are **more strongly attracted** to the nucleus as there are **more protons than electrons**.; / In O^+ ion, there is less inter-electronic repulsion as there is 1 fewer electron. OWTTE [1]~~

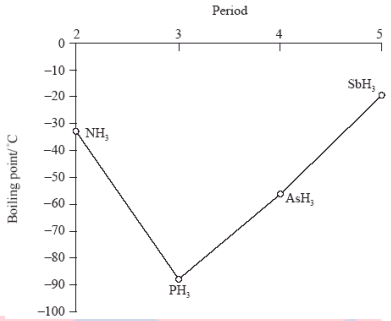
6 Group 15 elements react with hydrogen to form hydrides. The type of bond formed can be determined by the difference in electronegativity.

electronegativity difference	type of bond
0.0 – 0.2	non-polar covalent
0.3 – 1.4	polar covalent
> 1.5	ionic

(a) Define the term electronegativity. [2]

Electronegativity is the relative attraction that an atom [1] has for the shared electrons in a covalent bond. [1]

(b) The boiling points of some hydrides are shown in the graph below.



(i) State and explain the boiling point trend seen in the graph above from PH_3 to SbH_3. [2]

Boiling points **increases** [1] going down the group (from PH_3 to AsH_3 to SbH_3)
Relative molecular mass / number of electrons increases down the group leads to stronger London dispersion forces [1]

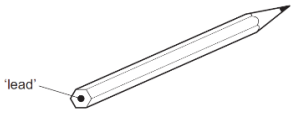
(ii) Explain why NH_3 is an exception. [1]

NH_3 has a higher boiling point than expected due to the intermolecular hydrogen bonding which is stronger than dipole-dipole forces holding other hydride molecules together.

(c) Using the VSEPR theory, draw the Lewis structure of the NH_3 molecule and state its bond angle and shape. [4]

correct bonds between H and N [1]
lone pair of electrons on N [1]
Bond angle: < 109.5° [1]
Shape: trigonal pyramidal [1]

7 The 'lead' in a pencil is made of a mixture of graphite and clay.

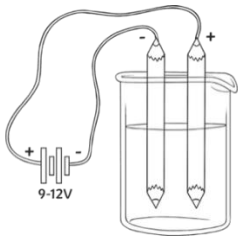


(a) When the percentage of graphite is increased, the pencil slides across the paper more easily. *[2]*

Explain this observation using the structure and bonding present in graphite.

Weak London dispersion forces exist **between the layers of carbon atoms** in **giant molecular structure of graphite.** [1]
As the percentage of graphite increases, there are **fewer clay particles to disrupt the structure** so the **layers of atoms can slide over each other more** [1]

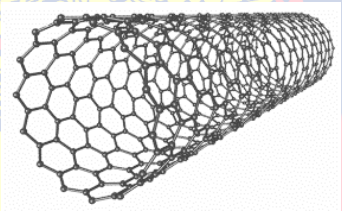
(b) Electrolysis is a process where electricity is used to break down or decompose a substance. Pencil 'lead' can be used as an electrode for electrolysis. The diagram below shows how two pencils are used in this process. *[2]*



Explain why pencil 'leads' can be used in the above set-up successfully.

The graphite in the pencil **can conduct electricity** [1]
due to the **presence of mobile delocalised electrons that act as charge carriers.** [1]

(c) Graphite is an allotrope of carbon. Carbon nanotubes are also allotropes of carbon as shown below. *[2]*



Based on the structure above, would you expect its melting point to be high or low? Explain.

High melting point [1]
Large amount of energy is required to **overcome the strong covalent bonds between the carbon atoms in giant molecular structure** [1]

(d) Tin (Sn), is another element from Group 14 that has allotropic forms at r.t.p. *[2]*

α-Sn, (grey tin) is the stable form below 13°C and has a diamond-like structure.

β-Sn (white tin) is metallic and has a close-packed lattice.

Deduce which allotrope of tin is malleable and suggest a use for it.

White tin or β-Sn is malleable [1] and can be used to make metallic sheets, cans, soldering, alloys such as bronze, sculptures, hammer [1]

8 Group 1 metals, also known as Alkali Metals, are very reactive metals.

(a) Write a balanced chemical equation, with state symbols, for the reaction between lithium and water. [2]

$2Li\ (s) + 2H_2O\ (l) \rightarrow 2LiOH\ (aq) + H_2\ (g)$
[1 – balanced chemical equation] ; [1 – state symbols]

(b) Potassium is below lithium in Group 1. Its hydroxide is typically reacted with iodine to prepare potassium iodide as shown below.

$$3I_2 + 6KOH \rightarrow 5KI + KIO_3 + 3H_2O$$

(i) The completion of the reaction can be determined by a colour change in the solution. State the expected observation in the reaction mixture. [1]

Brown solution turned colourless.

(ii) Potassium iodide is commonly used as a test reagent. State whether it is expected to be an oxidising agent or a reducing agent. [1]

Reducing agent

(c) Sodium is between lithium and potassium in the group. [1]

(i) State the order of reactivity for the three metals starting from the least reactive to the most reactive.

Reactivity: Li < Na < K

(ii) State whether Alkali metals have reducing or oxidizing power and determine which amongst lithium, sodium, and potassium would be the strongest one. [2]

Reducing power [1]
Potassium will be strongest one [1]

9 The element antimony, Sb, is usually found in nature as its sulfide ore, stibnite having the formula Sb_2S_3. This ore was used two thousand years ago by ancient Egyptian women as a cosmetic to darken their eyes and eyelashes.

(a) One method of extracting antimony from its sulfide ore is to roast stibnite in air. This forms antimony oxide and sulfur dioxide:

Reaction **1**: $2Sb_2S_3 + 9O_2 \rightarrow 2Sb_2O_3 + 6SO_2$

The antimony oxide then undergoes the following reaction:

Reaction **2**: $2Sb_2O_3 + 3C \rightarrow 4Sb + 3CO_2$

(i) Explain, using oxidation states, if the sulfur in Sb_2S_3 is reduced or oxidised in reaction **1**. [3]

Sulfur in Sb_2S_3 is **oxidised** [1] as the oxidation state of sulfur increases **from -2 in Sb_2S_3** [1] **to +4 in SO_2** [1]

(ii) Determine whether carbon behaves as an oxidising agent or a reducing agent in reaction **2.** [1]

Reducing agent

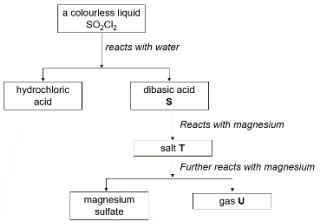
(B) Antimony reacts with concentrated nitric acid to form another oxide. [2]

$4Sb + 20HNO_3 \rightarrow Sb_4O_{10} + 20NO_2 + 10H_2O$

Determine the oxidation state of antimony in its oxides and fill in the table below.

oxide	**oxidation state of antimony**
Sb_2O_3	+3
Sb_4O_{10}	+5

10 Sulfuryl chloride, SO_2Cl_2 is a colourless liquid with a pungent smell. It reacts with water to form hydrochloric acid and a dibasic acid.



(a) Construct a chemical equation, including state symbols, for the reaction between sulfuryl chloride and water. *[2]*

SO_2Cl_2 (l) + $2H_2O$ (l) → 2HCl (aq) + H_2SO_4 (aq)
[1 – balanced chemical equation] ; [1 – state symbols]

(b) Give the name of salt **T** produced. *[1]*

magnesium hydrogensulfate (accept: magnesium bisulfate)

(c) Identify gas **U** and describe a test to confirm the gas. *[2]*

Hydrogen or H_2 [1]
The gas extinguishes a lighted splint with a 'pop' sound. [1]

11 **(a)** Both hydrochloric acid and ethanoic acid, CH_3COOH are monobasic acids. Hydrochloric acid is a strong acid while ethanoic acid is a weak acid.

(i) With the aid of a chemical equation, explain why ethanoic acid is a weak monobasic acid. [3]

CH_3COOH (aq) ⇌ H^+ (aq) + CH_3COO^- (aq) (Arrhenius definition) or
CH_3COOH (aq) + H_2O (l) ⇌ H_3O^+ (aq) + CH_3COO^- (aq) (Bronsted-Lowry definition) [1]

Weak – Ethanoic acid **dissociates partially in water** to produce a **low concentration of hydrogen ions** as compared to strong acid of the same concentration; [1]

Monobasic – Each ethanoic acid molecule contains **one ionisable hydrogen atom per molecule that can form H^+ ion**; [1]

(ii) Ethanoic acid has a degree of dissociation of 1%. [2]

Calculate the pH of 0.200 mol dm^{-3} ethanoic acid. Give your answer correct to 1 decimal place.

Concentration of H^+ = 0.200 X 1% = 0.00200 mol dm^{-3} [1]
pH = -lg (0.00200) = 2.7 [1]

(b) Sodium ethanoate can be prepared by reacting sodium metal with ethanoic acid. Sodium ethanoate is soluble in water as shown below. [2]

$$CH_3COONa\,(aq) \rightarrow CH_3COO^-\,(aq) + Na^+\,(aq)$$

With the help of a reversible equation, state whether sodium ethanoate is a basic or acidic salt.

Sodium ethanoate is a **basic salt**. The ethanoate ions hydrolyse in water to give an alkaline solution/hydroxide ions. [1]
CH_3COO^- + H_2O ⇌ CH_3COOH + OH^- [1]