REGENT SECONDARY SCHOOL
END-OF-YEAR EXAMINATION (SA2) - 2016
SECONDARY 3 EXPRESS
CHEMISTRY
(5073)

100

Name: _____ ( )

Date: 11 October 2016

Class: Sec 3-9

Duration: 2h 30 mins

INFORMATION TO CANDIDATES:

This paper consists of Sections A, B and C.

A copy of the Periodic Table of Elements is attached at Page 36 of the exam paper.

The marks allocated for each question or parts of a question are given in the brackets [ ].

INSTRUCTIONS TO CANDIDATES:

Do not turn over the pages until you are told to do so.

Section A

There are **30** multiple-choice questions.
Answer **all** the questions in this section in the OMR Answer Sheet by shading the appropriate oval with a 2B pencil.

Section B

Section B consists of 6 Structured Questions.
Answer all the questions in the spaces provided.

Section C

Section C consists of 3 Free-Response Questions.
Answer **all** the questions in the spaces provided. All workings and calculations must be shown clearly.

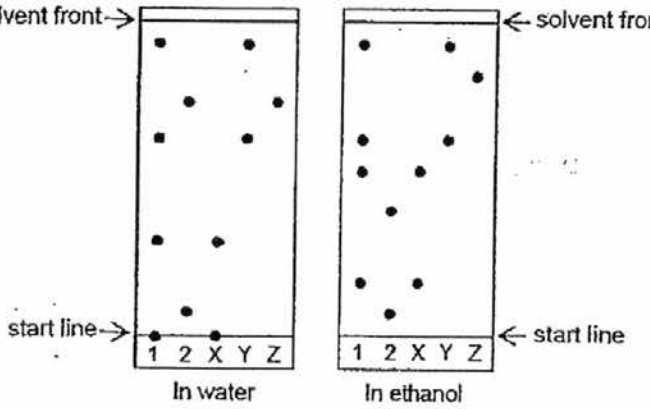
Hand in the OMR Answer Sheet and question paper separately.

This paper consists of 36 printed pages.
Section A : Multiple Choice Questions [30 marks]

2h2

Choose the correct answer and shade it in the spaces provided on the OMR.

A1 Food dyes, **1** and **2** are known to contain one or more of three substances **X**, **Y** and **Z**. Two Chromatograms are developed; one used water as the solvent, and the other used ethanol. The results are shown in the diagram below.



Which of the following statement(s) is/are correct?

I There is a component in Sample 1 that is insoluble in water but soluble in ethanol.

II The component in **Z** is more soluble in water than in ethanol.

III Substance **Z** is likely to be pure.

A I only

B II only

C I and III

D II and III

A2 What is the best method to separate a mixture of sodium chloride crystals and iodine crystals?

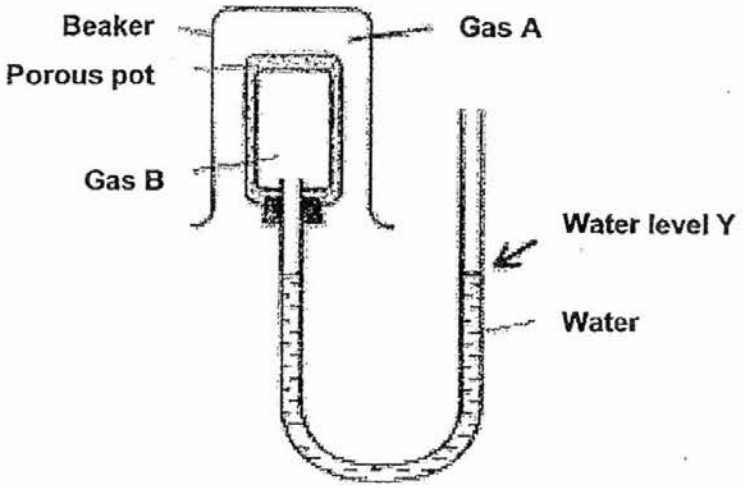
A Sublimation

B Fractional distillation

C Filtration

D Crystallisation

A3 A student uses the following apparatus to carry out a series of experiments to compare the rate of diffusion between different gases **K**, **L**, **M** and **N**.



The table below summaries the observations made.

Experiment	Gas A	Gas B	Observations after 5 min
1	**K**	**L**	Water level **Y** rises
2	**M**	**N**	Water level **Y** falls
3	**L**	**N**	Water level **Y** rises

Which of the following correctly lists the gases in order of increasing relative molecular mass?

A **K, L, M, N**

B **K, L, N, M**

C **M, N, L, K**

D **M, L, N, K**

243

A4 A giant molecule is made up of a large amount of carbon, mainly isotopes ^{12}C and ^{13}C. It was found that the average relative atomic mass of carbon in the molecule is 12.2.

What is the ratio by mass of ^{12}C to ^{13}C?

A 4 : 1

B 1 : 4

C 3 : 4

D 3 : 1

A5 The following statements give the description of four different substances, **K**, **L**, **M** and **N**.

I Solid **K** melts on heating to form a yellow liquid that cannot be made into a simpler substance.

II A chemical reaction takes place and heat is liberated when white solid **L** is formed.

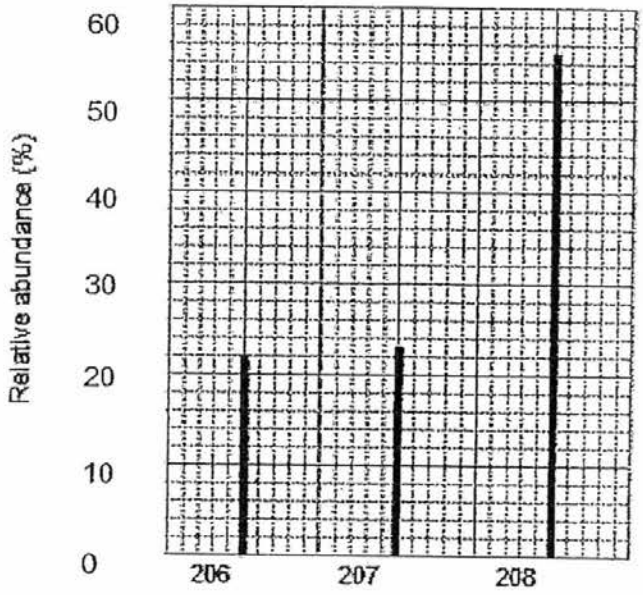
III Colourless substance **M** has a fixed melting point and a fixed boiling point.

IV When blue liquid **N** is distilled, a colourless liquid is collected.

Which row show the correct classification of substances, **K**, **L**, **M** and **N**?

	K	L	M	N
A	Compound	Compound	Element	Mixture
B	Element	Element	Mixture	Compound
C	Element	Compound	Element	Mixture
D	Mixture	Element	Compound	Compound

A6 Element **X** has three isotopes, ^{206}X, ^{207}X and ^{208}X. The graph below shows the relative isotopes.



What is the relative atomic mass of **X**?

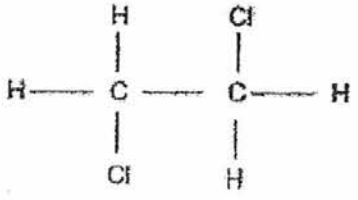
A 206.8

B 207.0

C 207.3

D 207.5

A7 The structure of dichloroethane is shown below.



How many electrons in a molecule of dichloroethane are **NOT** involved in bonding?

A 7

B 14

C 18

D 36

A8 The information about two particles, **X** and **Y** is given below.

What is the relative molecular mass of the compound formed by **X** and **Y**?

Atom	Number of neutrons	Electronic configuration
X	18	2,8,7
Y	14	2,8,4

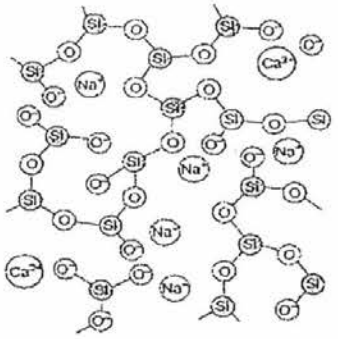
A 32

B 63

C 86

D 168

A9 A flame cauldron is specially designed and created for every Olympic game. One of the materials commonly used is soda-lime glass as it can withstand high temperature of over 2000°C when the cauldron is lit during each opening ceremony. The structure of soda-lime glass is shown below.



Soda-lime glass is prepared by melting calcium carbonate, sodium carbonate and silicon dioxide in a furnace.

What bond(s) is/are present in soda-lime glass?

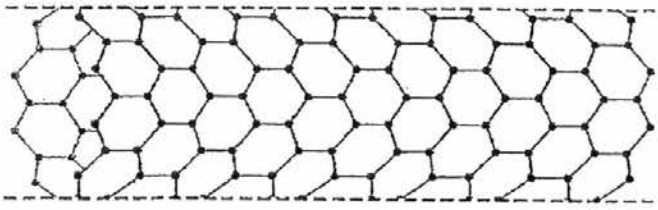
A Covalent only

B Covalent and ionic only

C Ionic and metallic only

D Metallic and covalent only

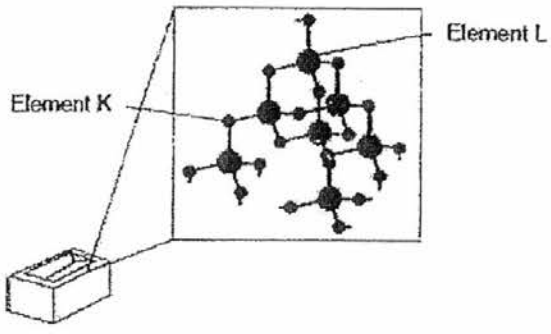
A10 Carbon nanotubes have been made by scientists in recent years. The structure is shown below:



Which one of the following would most likely be the properties of nanotubes?

	[illegible]	[illegible]	[illegible]
A	High	Insoluble	Good
B	High	Soluble	Poor
C	Low	Insoluble	Poor
D	Low	Soluble	Good

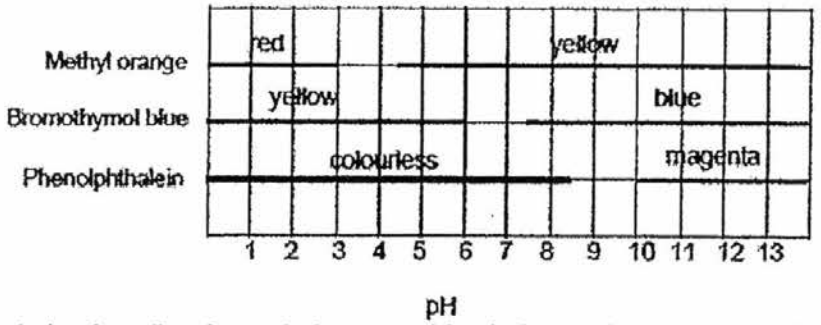
A11 A major component of bricks is a compound consisting of elements **K** and **L** chemically combined together.



What are elements **K** and **L**?

	Element K	Element L
A	Carbon	Silicon
B	Silicon	Carbon
C	Oxygen	Silicon
D	Silicon	Oxygen

A12 The graph shows the colour ranges of the acid-base indicators methyl orange, bromothymol blue and phenolphthalein.



A solution is yellow in methyl orange, blue in bromothymol blue and colourless in phenolphthalein.

What is the pH range of the solution?

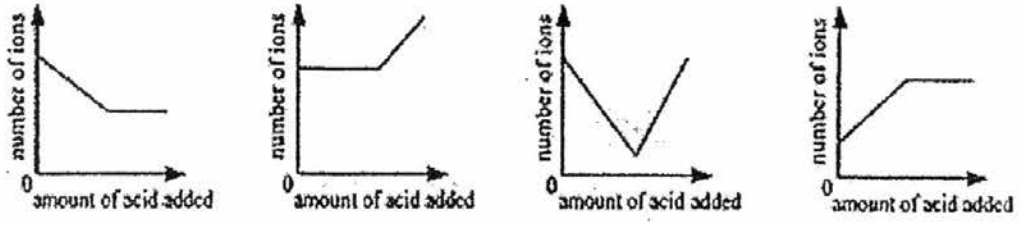
A 4.5 to 6.0

B 6.0 to 7.5

C 7.5 go 8.5

D 8.5 to 10.0

A13 Dilute sulfuric acid was added to aqueous barium hydroxide until the acid was in excess. Which graph best represents the variation in the total number of ions in solution?



A B C D

A14 Ammonium chloride was heated as shown in the diagram below. The equation for the reaction is $NH_4Cl \rightarrow NH_3 + HCl$. If a damp red litmus paper was held at the mouth of the test tube, what observation can be made?

A The damp red litmus paper would turn blue and then turn red.

B The damp red litmus paper would turn blue and remain blue.

C The damp red litmus paper will remain red.

D The damp red litmus paper will be bleached white.

A15 Chlorine gas is a severe irritant to the eyes and respiratory system. The maximum safe toleration level of chlorine gas in air is 0.005 mg dm^{-3}.
How many molecules of chlorine gas are present in 1 dm^3 of air at this toleration level? (*Note: 1g =1000 mg*)

A $0.005/ 6 \times 10^{23} \times 71$

B $0.005/71 \times 6 \times 10^{23}$

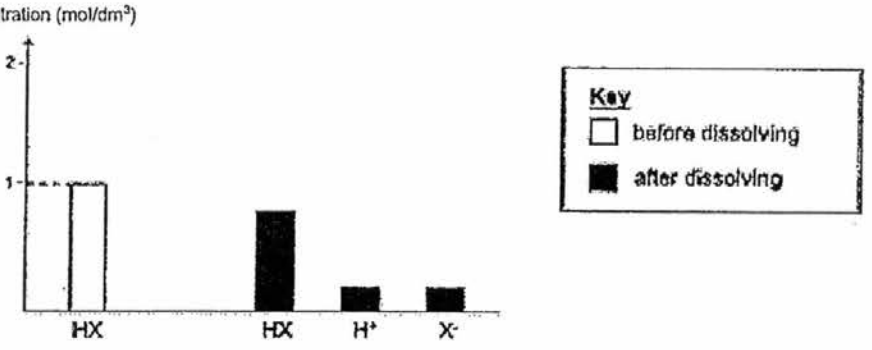
C $0.005/1000 \times 1/71 \times 6 \times 10^{23}$

D $0.005/1000 \times 71 \times 6 \times 10^{23}$

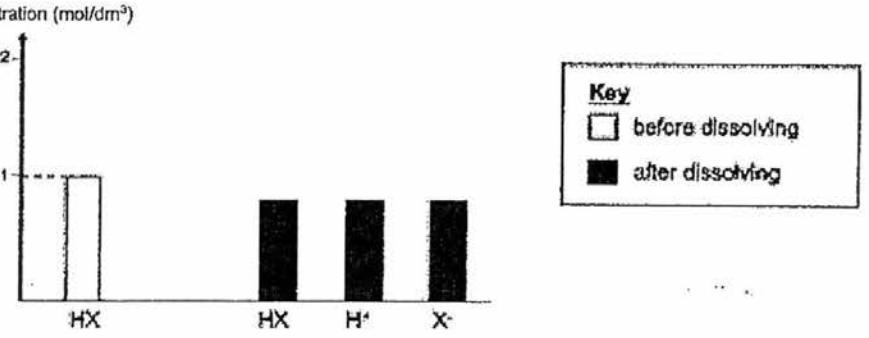
24 L

A16 Which graph shows the solution formed when one mole of a **weak acid**, HX is dissolved in 1 dm^3 of water?

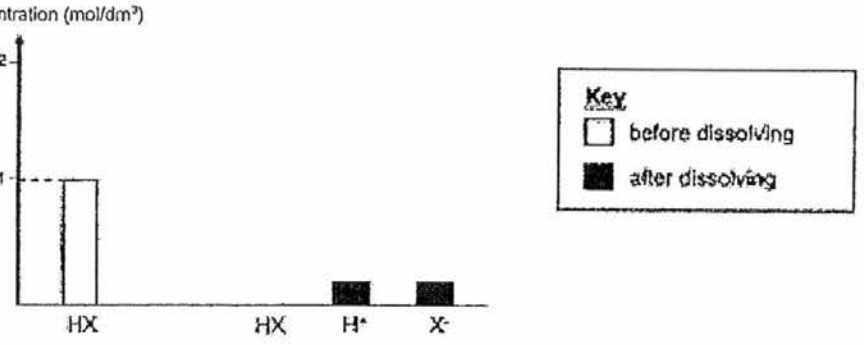
A



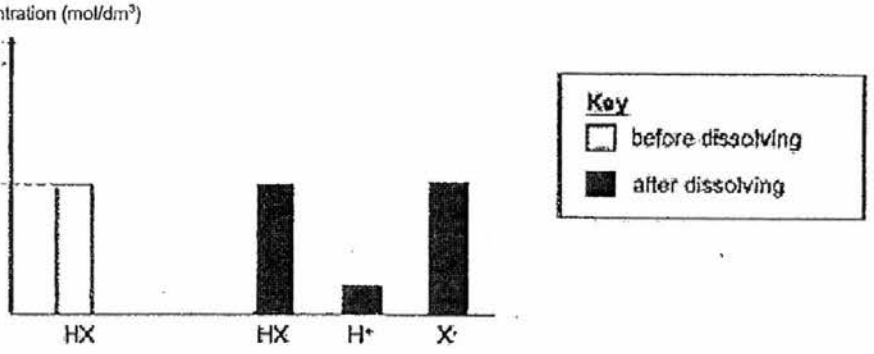
B



C



D



A17 In a pathology laboratory, a sample of urine containing 0.120 g of urea, NH_2CONH_2 (M_r = 60) was treated with an excess of nitrous acid. The urea reacted according to the following equation.

$$NH_2CONH_2 + 2HNO_2 \rightarrow CO_2 + 2N_2 + 3H_2O$$

The gas produced was passed through aqueous sodium hydroxide and the final volume measured.

What was this final volume of gas left behind at room temperature and pressure?

A 9.6 cm^3

B 14.4 cm^3

C 48.0 cm^3

D 96.0 cm^3

A18 On collision, airbags in cars inflate rapidly due to the production of nitrogen. The nitrogen is formed according to the following equations.

$$2NaN_3 \rightarrow 2Na + 3N_2$$
$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas is produced from 1 mol of sodium azide, NaN_3?

A 1.5

B 1.6

C 2.0

D 4.0

A19 Which acid contains the greatest number of hydrogen ions?

A 150 cm^3 of 3 mol/dm^3 sulfuric acid

B 250 cm^3 of 2 mol/dm^3 nitric acid

C 250 cm^3 of 3 mol/dm^3 hydrochloric acid

D 300 cm^3 of 3 mol/dm^3 ethanoic acid

A20 The table gives the concentrations and pH values of the aqueous solutions of two compounds, **X** and **Y**. Either compound could be an acid or a base.

Concentration	2 mol/dm^3	2 mol/dm^3
pH	6	9

Student **P** concluded that **X** is a strong acid.
Student **Q** concluded that the extent of dissociation is lower in **X** (aq) than in **Y** (aq).

Which of the students is/are correct?

A Both **P** and **Q**
B Neither **P** nor **Q**
C **P** only
D **Q** only

A21 Which of the following statements are true about the elements in Group I of the Periodic Table?

1 Their melting points decreases down the group.
2 The ionic radius increases down the group.
3 Their reactivities decrease on descending down the group.

A 1, 2 and 3
B 1 and 2 only
C 2 and 3 only
D 1 only

A22 The table below gives the relative concentrations of polluting gases in the air in four different industrialised cities. In which city, **A**, **B**, **C** or **D**, are limestone buildings most threatened by pollution?

	[illegible]	[illegible]	[illegible]
A	17	46	23
B	32	33	30
C	38	40	11
D	45	14	21

A23 A salt has the formula $(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$.

Which of the following is/are the expected observation(s) when an aqueous solution of this salt is treated with aqueous sodium hydroxide solution?

I Formation of a dirty green precipitate
II Formation of a brown precipitate
III Evolution of a gas with a pungent odour

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

A24 Excess aqueous iodine is added to a mixture of sodium chloride and sodium bromide solutions in a beaker. Which particles will be present in the resulting mixture?

A Iodine atoms, sodium ions, chloride ions and bromide ions
B Iodine atoms, sodium atoms, chlorine atoms, bromine atoms
C Iodide ions, sodium ions, chlorine molecules and bromine molecules
D Iodine molecules, sodium ions, chloride ions and bromide ions

A25 Boron is a non-metallic element which is placed above aluminium in Group III of the Periodic Table. It forms a compound with nitrogen known as boron nitride which has a graphite structure.

Which of the following conclusions can be drawn from this information?

I The empirical formula of boron nitride is BN

II The boron and nitrogen atoms are likely to be arranged alternately in a hexagonal pattern.

III Boron nitride has a layer structure with weak attraction forces between the layers.

A I and III only

B I and II only

C II and III only

D All of the above

A26 Elements **X** and **Y** are in Group VII of the Periodic Table. At room temperature, **X** is a liquid and **Y** is a solid. Which of the following is correct?

I Atoms of **Y** have more protons than atoms of **X**.

II Molecules of **X** have the same number of atoms as molecules of **Y**.

III **X** displaces **Y** from an aqueous solution containing ions of **Y**.

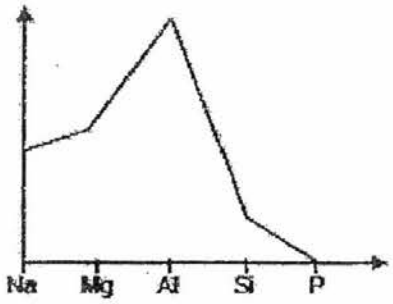
A I and II only

B II and III only

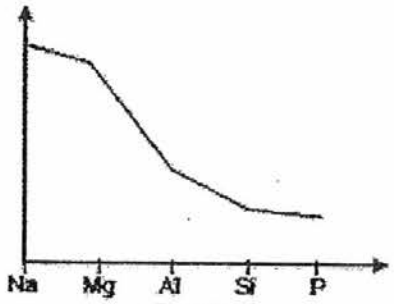
C I and III only

D All of the above

A27 The graphs below show the variation in two properties of the elements Na to P and their compounds.



Graph I



Graph II

Which properties are illustrated in Graphs I and II?

	Graph I	Graph II
A	Electrical conductivity of the element	pH of the chloride when added to water
B	Electrical conductivity of the element	pH of the oxide when added to water
C	Melting point of the element	pH of the chloride when added to water
D	Melting point of the element	pH of the oxide when added to water

A28 To reduce atmospheric pollution, the following waste gases from a coal burning power station are passed through wet powdered calcium carbonate.
How many waste gases will **not** be removed by the wet powdered calcium carbonate?

carbon monoxide	carbon dioxide	nitrogen monoxide
nitrogen dioxide	sulfur dioxide	phosphorus(V) oxide

A 1
B 2
C 3
D 4

24?

A29 The results of three halogen displacement experiments are shown.

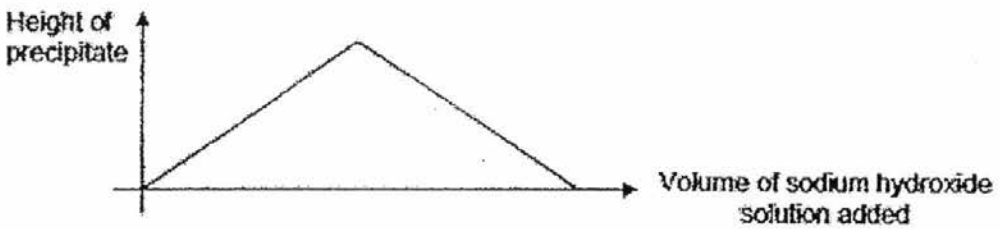
The table shows the results.

Experiment	Halogen added	Halide solution		
		X^-	Y^-	Z^-
1	X_2	-	Y_2 displaced	Z_2 displaced
2	Y_2	No reaction	-	No reaction
3	Z_2	No reaction	Y_2 displaced	-

What are halpgens **X**, **Y** and **Z**?

	X	Y	Z
A	Br	Cl	I
B	Br	I	Cl
C	Cl	Br	I
D	Cl	I	Br

A30 An aqueous solution of a salt, **X**, is placed in a test tube and sodium hydroxide solution is gradually added. The height of the precipitate in the test tube is plotted against the volume of sodium hydroxide added.



Which cation is found in **X**?

A Aluminium ion

B Ammonium ion

C Copper (II) ion

D Iron (II) ion

Section B: Structured Questions [40 marks]

Answer all the questions in the spaces provided.

B1 Choose from the following equations to answer the questions below.

A	$S(s) + O_2(g) \rightarrow SO_2(g)$
B	$MgO(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l)$
C	$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$
D	$ZnO(s) + 2NaOH(aq) \rightarrow Na_2ZnO_2(aq) + H_2O(l)$
E	$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$
F	$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$
G	$NH_4NO_3(s) + NaOH(aq) \rightarrow NaNO_3(aq) + NH_3(g) + H_2O(l)$
H	$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

Each equation can be used once, more than once or not at all.

Give the letter of an equation which

(a) shows the reaction which produces a salt by titration, [1]

(b) shows the reaction of an amphoteric oxide with a base, [1]

(c) shows the formation of a gas that turns moist red litmus blue, [1]

(d) shows a reaction in a catalytic converter, [1]

250

B1 (e) shows a reaction that produces a gas that causes acid rain. [1]

B2 Lead compounds are extensively used to provide the colour in paints and pigments.

'White lead', used for over 2000 years as a white pigment, is based on lead carbonate. Analysis shows that lead carbonate has the following percentage composition by mass:

Pb : 77.5% C : 4.5% O : 18.0%

'Red lead', is the pigment in paint used as a protective coating for structural iron and steel. It is based on lead (IV) oxide, Pb_3O_4, a scarlet powder formed by combining lead (II) oxide powder with oxygen.

(a) Calculate the empirical formula of lead carbonate. [3]

(b) Write a chemical equation for the formation of the 'scarlet powder'. State symbols are **not** required. [1]

B2 (c) Calculate the mass of Pb_3O_4 that could be formed from 66.9 g of PbO. [2]

B3 Rubidium, Rb, is a highly reactive element in Group I of the Periodic Table.

The table below shows some information about two isotopes of rubidium.

Atomic symbol of isotopes	Number of protons	Number of electrons	Number of neutrons	Relative abundance
$^{85}_{37}Rb$	37			72.2
	37		50	27.8

(a) Complete the table above. [2]

(b) A sample of rubidium has the isotopic composition by mass shown in the table above.

Calculate the relative atomic mass of rubidium based on the data given in the table. Give your answer to **3 significant figures.** [2]

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B3 (c) Rubidium has the following properties.

(i) Rubidium reacts violently with cold water.

Write an equation, including state symbols, to show the reaction of rubidium with water. [2]

(ii) Rubidium is a good conductor of electricity.

Describe, with the aid of a labelled diagram, the structure of a metal and use it to explain why rubidium is a good conductor of electricity. [2]

Diagram:

B4 The following table shows some substances and their properties.

Substance	Melting point / °C	Boiling point / °C	Solubility in water	Electrical conductivity when solid	Electrical conductivity when liquid
A	3550	4830	insoluble	poor	poor
B	-55.6	-78.5	slightly soluble	poor	poor
C	1085	2562	insoluble	good	good
D	801	1413	soluble	poor	good
E	-38.8	357	insoluble	good	good

(a) Give the letter of the substance that is likely to have a [3]

(i) simple molecular structure _____

(ii) giant molecular structure _____

(iii) giant metallic structure _____

(b) Explain the electrical conductivity of **D** in the solid and the molten state. [3]

_____

_____

_____

_____

_____

_____

_____

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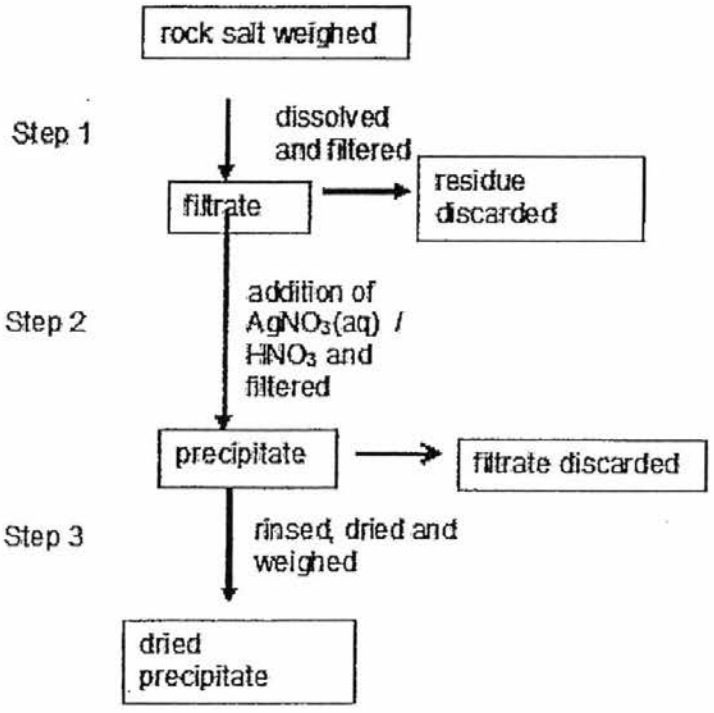
B5 Rock salt (NaCl) is an ionic compound that occurs naturally as white crystals. It is extracted from the mineral form halite or evaporation of seawater.
The flowchart outlines the steps used to determine the percentage of sodium chloride present in a sample of rock salt of mass 2.5 g.



(a) Give the ionic equation for the formation of the precipitate formed in Step 2. [1]

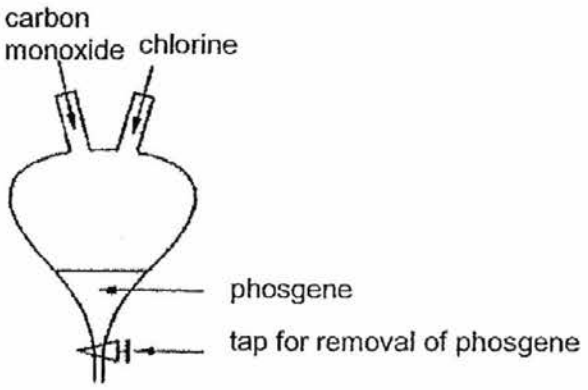
(b) Explain what precautions must be taken in Steps 2 and 3 to ensure accuracy of results. [2]

B5 (c) At the end of the experiment the mass of the precipitate was found to be 5.74 g. Calculate the percentage of sodium chloride in the rock salt sample. [3]

(d) Suggest another test to show that the rock salt is impure. [2]

B6 Carbonyl chloride, $COCl_2$, is a colourless and poisonous gas that is known as phosgene. It is used a chemical weapon during World War I where it was responsible for about 85 % of the 100 000 deaths caused by chemical weapons.

It is produced from the reaction of carbon monoxide and chloride gas in the reaction vessel as shown in the diagram below.



(a) Describe a chemical test to distinguish between carbon monoxide gas and chlorine gas. [2]

(b) Using the key provided, draw a 'dot and cross' diagram to show the bonding in phosgene.
Only the outer shell electrons need to be shown. [2]

● represent electrons of O
X represent electrons of C
O represent electrons of Cl

B6 (c) Explain why phosgene exists as a gas at room temperature. [2]

(d) Write a full chemical equation for the formation of phosgene. [1]

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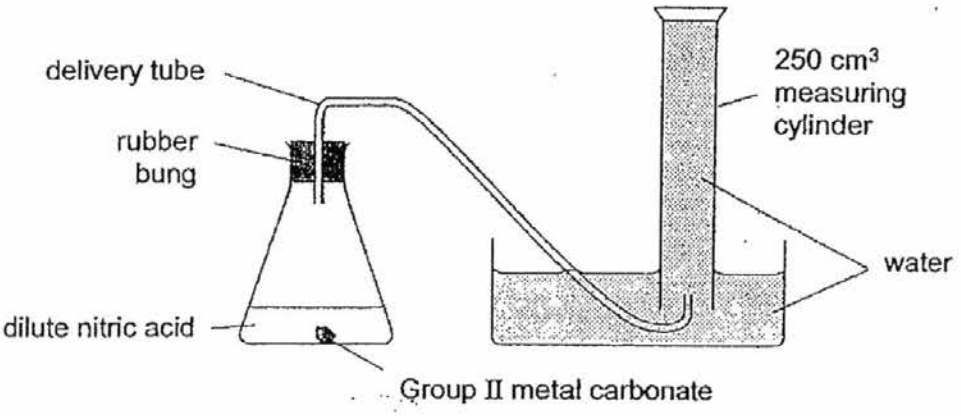
Section C : Free Response Questions [30 marks]

Answer all three questions.
Write your answers in the spaces provided.

C1 (a) A student set up this apparatus to measure the volume of carbon dioxide given off when a sample of carbonate of a Group II metal was reacted with dilute nitric acid.



She weighed out some of the carbonate and put it in a conical flask. She then added an excess of dilute nitric acid.

After adding the acid she placed the bung and delivery tube into the conical flask. She measured the total volume of gas collected in the measuring cylinder.

Her results are shown in the table below.

Mass of carbonate / g	0.888
Volume of gas collected / cm³	144

The equation for the reaction is

$$\mathbf{X}CO_3\,(s) + 2\,HNO_3\,(aq) \rightarrow \mathbf{X}(NO_3)_2\,(aq) + H_2O\,(l) + CO_2\,(g)$$

where **X** is the symbol for the Group II metal.

(i) Assuming the reaction took place at room temperature and pressure, calculate the number of moles of carbon dioxide gas collected. [1]

C1 (a) (ii) Calculate the number of moles of the carbonate that reacted. [1]

(iii) Using the mass of the carbonate and your answer to (ii), calculate the relative molecular mass of this carbonate. Give your answer to the nearest whole number. [2]

(iv) Calculate a value for the molar mass of the Group II metal **X**, and use the Periodic Table to suggest its identity. [2]

(v) The student repeated the experiment at another laboratory to confirm the validity of it. She had used the same mass of the carbonate. However, the volume of carbon dioxide produced had increased and it was inconsistent with her calculations. There was no problem with the student's experimental techniques and no problem was found with the experimental set-up.

Suggest and explain a reason for the unexpected result. [1]

_____

_____

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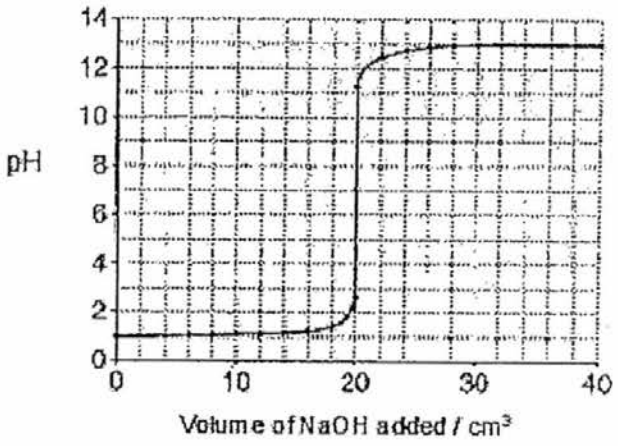
C1 (b) A pH meter and a data logger are commonly used to monitor changes in pH during a titration.

The two graphs below show how pH changes when two different acids were used when alkali was added from a burette. The alkali used in each titration was the same, 0.100 mol/dm^3 NaOH.

Graph 1:



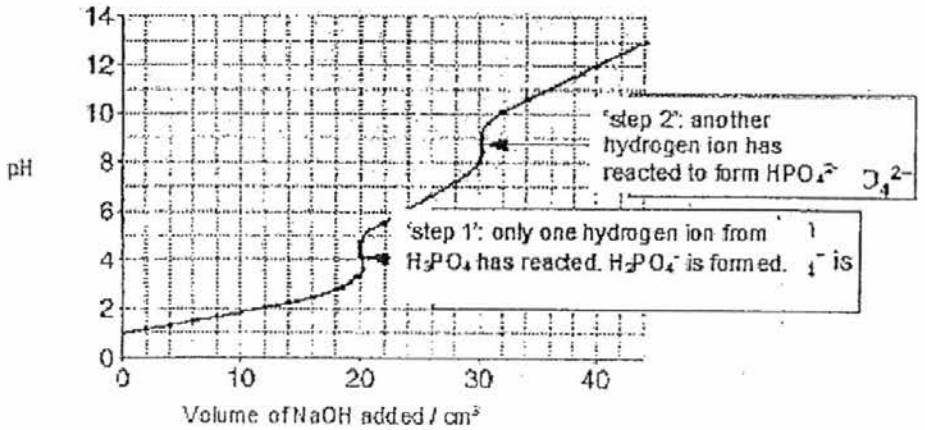
Graph 1 was obtained using sulfuric acid. Sulfuric acid is a strong acid. The ionisation of sulfuric acid can be shown by two equations:

1. $H_2SO_4 \rightarrow H^+ + HSO_4^-$

2. $HSO_4^- \rightarrow H^+ + SO_4^{2-}$

There is only a single 'step' on the graph.

Graph 2:



C1 (b) Graph 2 is obtained using phosphoric acid (H_3PO_4), a weak acid. There are two 'steps' on the graph.

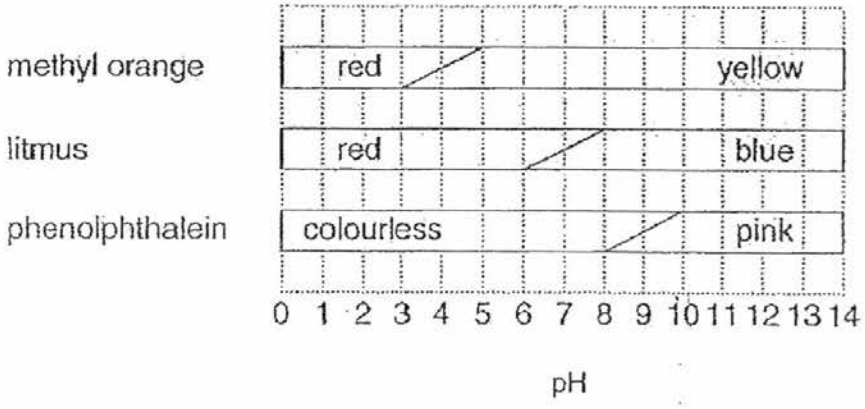
(i) Explain the difference between sulfuric acid and phosphoric acid in terms of their strength. [1]

(ii) Write equations to show how phosphoric acid produces the hydrogen ions involved in the two 'steps' shown in Graph 2. [2]

Step 1: _____

Step 2: _____

(iii) Other than a pH meter or data logger, indicators can also be used to see when a 'step' happens.
The endpoint of each titration happens when the indicator used changes colour.
The diagram below shows the colours of some typical indicators at different pH values.



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C1 (b) (iii) Explain why all three indicators in the diagram can be used to give an accurate titration volume when sulfuric acid is titrated with sodium hydroxide. [2]

C2 One of the largest uses of phosphorus is in the making of safety matches. A safety match ignites when it is rubbed against the striking of a match box.

The match head contains the following substances:

- Phosphorus, P_4
- Potassium chlorate (V), $KClO_3$
- A hydrocarbon wax

(a) The friction between the match head and the striking surface generates enough heat for phosphorus to burn.

Phosphorus burns to form phosphorus (V) oxide.

Suggest one physical and one chemical property of phosphorus (V) oxide. [2]

Physical property : _____

_____

Chemical property : _____

_____

(b) Suggest how you can prove that phosphorus is an element and hydrocarbon wax is a mixture. [2]

_____

_____

_____

(c) When potassium chlorate (V), $KClO_3$, is heated at 600°C, it decomposes into potassium chloride and oxygen.

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

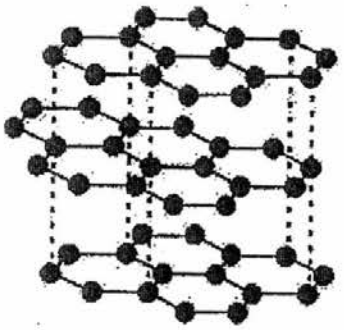
Copper (II) oxide is said to act as a catalyst for the reaction.
Some information of these compounds are shown in the table below.

	KCl	$KClO_3$	CuO
Melting point / °C	772	368	1326
Boiling point / °C	1407	-	-

C2 (c) (i) If you had a mixture of potassium chloride, copper (II) oxide and potassium chlorate (V), how would you obtain pure copper (II) oxide from the mixture? [2]

(ii) Describe how you would prepare a pure sample of copper (II) carbonate in the school laboratory using copper (II) nitrate as one of the starting reagents. [2]

C3 (a) The diagram below shows the structures of graphite and silicon dioxide.



graphite

silicon dioxide

(i) Describe the difference between the structure of silicon dioxide and graphite. [2]

(ii) Compare and explain the electrical conductivity of silicon dioxide and graphite. [2]

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C3 (a) (iii) Diamond has a melting point of 3550 °C and the melting point of silicon dioxide is 1600 °C.

Explain the difference in the melting points of diamond and silicon dioxide. [2]

(b) Besides silicon dioxide, sand often contains small amounts of metal oxides.

When a sample is sand is treated with dilute hydrochloric acid and the mixture is filtered, the filtrate gives a brown precipitate **Q** with aqueous sodium hydroxide.

Identify what is brown precipitate **Q** and hence the metal oxide present in sand. [2]

Brown precipitate **Q** : _____

Metal oxide : _____

C3 (c) Aluminum oxide is the second-hardest mineral after diamond.

Aluminium oxide reacts with solutions of both acids and alkalis. It reacts with aqueous sodium hydroxide according to the following equation:

$$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$$

A student commented that he only needs to use the above reaction involving aqueous sodium hydroxide to confirm the nature of aluminium oxide.

Do you agree with the student? Explain your reasoning. [2]

END-OF-PAPER

'Seek to understand first, then Apply Past Knowledge To New Situations'

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The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	64 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 †															

*58-71 Lanthanoid series	140 Ce cerium 58	141 Pr Praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	162 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
†90-103 Actinoid series	232 Th thorium 90	– Pa protactinium 91	238 U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lr lawrencium 103

Key: relative atomic mass / atomic symbol / name / atomic number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

REGENT SECONDARY SCHOOL

End-of-Year Examination 2016

Sec 3E Pure Chemistry Mark Scheme

SECTION A

Multiple Choice Questions (30 marks)

A1	C	A11	D	A21	B
A2	A	A12	C	A22	C
A3	B	A13	C	A23	C
A4	A	A14	A	A24	D
A5	C	A15	C	A25	D
A6	C	A16	A	A26	D
A7	D	A17	D	A27	D
A8	D	A18	A	A28	B
A9	B	A19	A	A29	D
A10	A	A20	B	A30	A

SECTION B (40 marks)

B1

(a)	**H**	1
(b)	**D**	1
(c)	**G**	1
(d)	**E**	1
(e)	**A**	1

B2

(a)

Taking 100 g	**Pb**	**C**	**O**	
Mass / g	**77.5**	**4.5**	**18**	
M_r	**207**	**12**	**16**	0.5 m
Number of moles / mol	**77.5 / 207 = 0.374**	**4.5 / 12 = 0.375**	**18 / 16 = 1.125**	1 m
Simplest ratio	**0.374 / 0.374 = 1**	**0.375 / 0.374 = 1**	**1.125 / 0.374 = 3**	1 m
Empirical Formula	**$PbCO_3$**			0.5 m

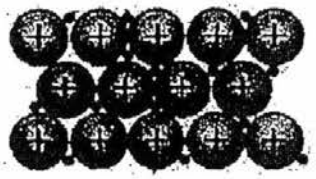
(b) $6PbO + O_2 \rightarrow 2Pb_3O_4$ — 1

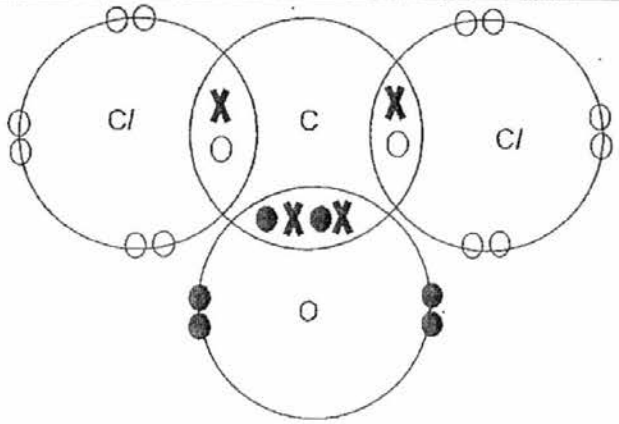
Correct formula – 0.5 mark
Correct balancing – 0.5 mark

(c)
M_r of PbO
= 207 + 16
= 223

Number of moles of PbO
= 66.9 / 223
= 0.3 mol — 0.5

From equation,
6 moles of PbO produces 2 moles of Pb_3O_4
0.3 moles of PbO produces 0.1 moles of Pb_3O_4 — 0.5

		M_r of Pb_3O_4 = 3(207) + 4(16) = 685 Number of moles of Pb_3O_4 = 0.1 X 685 = 68.5 g	0.5 0.5
B3	(a)	37; 48 $^{87}_{37}Rb$; 37 0.5 mark for each correct answers	2
	(b)	Relative atomic mass = 72.2/100*85 + 27.8/100* 87 = 85.6	1 1
	(c)(i)	$2Rb\ (s) + 2H_2O\ (l) \rightarrow 2RbOH\ (aq) + H_2\ (g)$ Correct formula and balancing – 1 mark Correct state symbols – 1 mark	2
	(c)(ii)	 Rubidium consist of **positive ions** in a **sea of delocalized electrons**. These **electrons are free and mobile**, hence they can **carry the electric current** from one end to another.	1 0.5 0.5
B4	(a)(i)	B	1
	(a)(ii)	**A**	1
	(a)(iii)	**C**	1
	(b)	In the solid state, ions of **D** are in **fixed positions** in the **crystal lattice** held by **strong electrostatic forces of attractions**, hence they are unable to move to conduct electricity. In the molten state, the ions are **no longer in their fixed positions in the crystal lattice.** Hence they can move around to carry the electric current from one end to another.	0.5 0.5 0.5 0.5 0.5 0.5

B5	(a)	$Ag^+ + Cl^- \rightarrow AgCl$	1
	(b)	In step 2 there must be excess of silver nitrate solution and nitric acid to ensure all chloride ions are precipitated. In step 3 the precipitate must be dried and weighed a number of time until a constant weight is obtained to ensure all water has evaporated from silver chloride.	1 1
	(c)	Number of moles of AgCl = 5.74 / 143.5 = 0.04 mol From equation, 1 mole of AgCl is produced from 1 mole of NaCl 0.04 mole of AgCl is produced from 0.04 mole of NaCl M_r of NaCl = 23 + 35.5 = 58.5 Mass of NaCl = 58.5 X 0.04 = 2.34 g % of NaCl = 2.34 / 2.5 X 100% = 93.6 %	0.5 0.5 0.5 0.5 1
	(d)	Carry out chromatography on the rock sample. If there is more than one spot it is impure Or Check the melting point of the rock sample. If it melts over a range of temperature it is impure.	1 1 1 1
B6	(a)	Place a piece of damp blue litmus paper into the gas If damp blue litmus paper turns red and then bleached, it is chlorine gas. If damp blue litmus paper remains blue, it is carbon monoxide	1 0.5 0.5
	(b)	 Correct number of electrons in overlap – 1 mark	2

		Correct number of unpaired valence electrons – 1 mark	
	(c)	Phosgene has a simple molecular structure held by weak van der waals' forces of attraction between molecules. Hence a small amount of heat energy is required to overcome these forces, resulting in a low boiling point, therefore it is a gas.	0.5 0.5 0.5 0.5
	(d)	$CO + Cl_2 \rightarrow COCl_2$	1

SECTION C (30 marks)

C1	(a)(i)	No. of moles of CO_2 = 144 / 24000 = 0.00600 mol	1
	(a)(ii)	From equation 1 mole of XCO_3 produces 1 mole of CO_2 0.006 mole of XCO_3 produces 0.006 mole of CO_2 No. of moles of Carbonate = 0.00600 mol Reject if mole ratio not given (question asked to calculate – must show working)	1
	(a)(iii)	Relative molecular mass = 0.888 / 0.006 = 148	1 1
	(a)(iv)	Ar of X = 148 – 12 – 3(16) = 88 X is strontium / Sr Ecf from part iii. Student can choose element which is closest to value obtained in part iii but must be a group II metal.	1 1
	(a)(v)	The temperature of the new lab was <u>higher</u> than room temperature/ 25°C. The volume occupied by one mole of gas would therefore be <u>greater than 24 dm^3</u>.	1
	(b)(i)	Sulfuric acid is a strong acid which dissociates <u>completely in water</u> to give a high concentration of <u>H^+</u> ions. Phosphoric acid is a weak acid which dissociates <u>partially in water</u> to give a low concentration of <u>H^+</u> ions.	0.5 0.5
	(b)(ii)	Step 1: $H_3PO_4 \rightarrow H^+ + H_2PO_4^-$ Step 2: $H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$	1 1
	(b)(iii)	The pH at which <u>all 3 indicators change colour</u> is <u>within the range of the 'step' from pH 3 to 11</u> during neutralisation.	1 1

C2	(a)	physical property It has low melting and boiling point [1]. chemical property It is an acidic oxide. It can react with base to form salt and water. [1].	2
	(b)	Heat both substance and measure its melting point Phosphorus melts at a fixed temperature. Hydrocarbon wax melts over a range of temperature.	1 0.5 0.5
	(c)(i)	Add water to the mixture to dissolve potassium chloride and potassium chlorate(V). Filter the resulting mixture to obtain copper(II) oxide as residue and wash it with distilled water.	1 0.5 0.5
	(c)(ii)	Add a fixed volume of barium nitrate solution and sodium chloride solution in a beaker. Upon stirring, a white precipitate of barium sulfate and sodium nitrate solution is formed. Filter the mixture. Barium sulfate is the residue and sodium nitrate solution is the filtrate Wash the residue with cold distilled water to remove any water-soluble impurities. Dry between pieces of filter paper to obtain pure dry barium sulfate.	0.5 0.5 0.5 0.5

C3	(a)(i)	In graphite, each carbon atom is bonded to 3 other carbon atoms in a hexagonal arrangement held by weak van der waals' forces of attraction in layers. In silicon dioxide, each silicon atom is bonded to four oxygen atoms in a tetrahedral structure held by strong covalent bonds.	0.5 0.5 0.5 0.5
	(a)(ii)	In silicon dioxide, each silicon atom uses all 4 valence electrons for bonding. Hence, there are no free and mobile valence electron to conduct electricity. In graphite, each carbon atom uses 3 out of 4 valence electrons for bonding. Hence there is 1 free and mobile valence electron per carbon atom available to conduct electricity.	0.5 0.5 0.5 0.5
	(a)(iii)	The carbon-carbon bond in diamond is stronger than the silicon-oxygen bond in silicon dioxide [1]. Hence, larger amount of energy is required to break the strong covalent bonds in diamond than the covalent bonds in silicon dioxide [1].	2
	(b)	**Q** is iron(III) hydroxide [1]. Iron(III) oxide is present in sand [1].	2
	(c)	No To show if the metal oxide is amphoteric, the student also needs to react the oxide with acids to check if it can form salt.	1 1