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KUO CHUAN PRESBYTERIAN SECONDARY SCHOOL
2016 END-OF-YEAR EXAMINATION

Secondary 3 Express

NAME

CLASS

REG. NO

CHEMISTRY (SPA)

7 October 2016

2 hours

Additional Materials: Multiple Choice Answer Sheet.

Setter: Mr. Desmond Tan

READ THESE INSTRUCTIONS FIRST

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

Section A

Answer **all** questions.

Write in soft pencil.

Do not use staples, paper clips, highlighters and glue or correction fluid.

Write your class, name and index number on the Multiple Choice Answer Sheet in the spaces provided.

There are **thirty** questions in Section **A**. 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 separate Multiple Choice Answer Sheet.

Section B

Answer **all** questions.

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

Write in dark blue pen.

You may use a soft pencil for any diagram, graphs or rough working.

Write your answers in the spaces provided in the Question Paper.

Section C

Answer all **three** questions, the last question is in the form either/or.

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

The number of marks is given in brackets [] at the end of each question or part question.

Periodic Table is given on **page 24**.

You are allowed to use calculators.

.....
Parent's signature/
Date

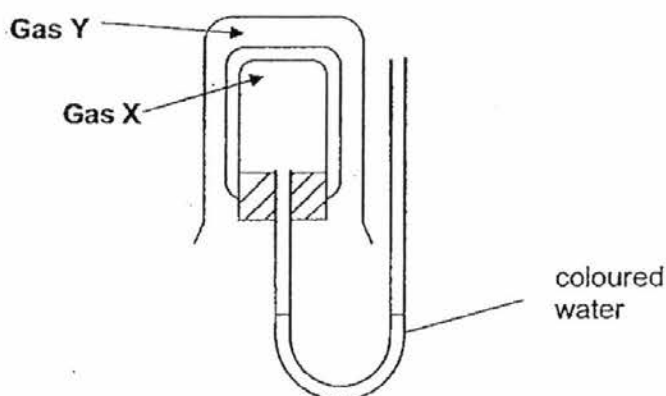
**FOR EXAMINER'S
USE**

Section A	/30
Section B	/40
Section C	/30
Total	/100

This document consists of **24** printed pages

Section A (30 marks)

- 1 In which change(s) is/are there a decrease in the spacing between particles?
- 1 condensation 2 freezing 3 sublimation
- A 1 and 2 only
 B 1 and 3 only
 C 2 and 3 only
 D 1, 2 and 3
- 2 Why does the temperature of boiling water remain constant even though heat is supplied at a constant rate?
- A The heat is converted to kinetic energy of the water molecules as they increase in speed.
 B The heat is lost to the surroundings.
 C The heat is used to break the covalent bonds in the water molecules.
 D The heat is used to overcome the intermolecular forces of attraction between water molecules.
- 3 The apparatus below can be used to show the diffusion of gases.

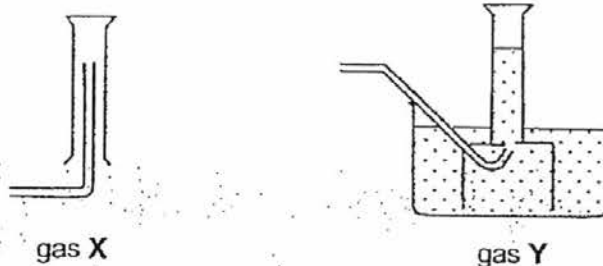


Which pair of gases X and Y would cause **no** movement of the coloured water?

	X	Y
A	C_2H_4	C_2H_6
B	C_2H_4	N_2
C	CO_2	C_2H_6
D	CO	NO_2

- 4 Which group of substances contains an element, a mixture, and a compound?
- A air, sea water, oxygen
 B copper, water, magnesium chloride
 C hydrogen, carbon, methane
 D oxygen, air, ammonia

- 5 Two liquids have the same boiling point and are immiscible in each other. Which method would you use to separate them?
- A chromatography
 B fractional distillation
 C simple distillation
 D use of a separating funnel
- 6 Gas X and gas Y can be collected by using the apparatus shown below.



Which of the following statements about gas X and gas Y is true?

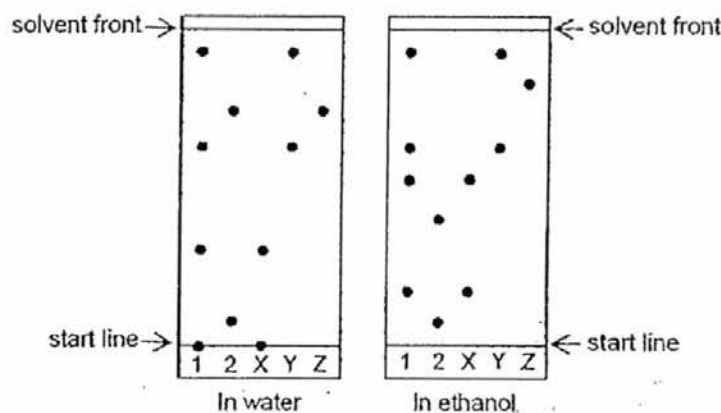
- A Gas X is denser than air, and gas Y is insoluble in water.
 B Gas X is less dense than air, and gas Y is insoluble in water.
 C Gas X is insoluble in water, and gas Y is denser than air.
 D Gas X is soluble in water, and gas Y is less dense than air.
- 7 The table shows the colours and the solubilities in water of four solids.

solid	colour	solubility in water
O	blue	insoluble
P	blue	soluble
Q	white	insoluble
R	white	soluble

A mixture containing two of the solids is added to excess water, stirred and filtered. A blue filtrate and a white residue are obtained. Which two solids are present in the mixture?

- A O and P
 B O and Q
 C P and Q
 D P and R

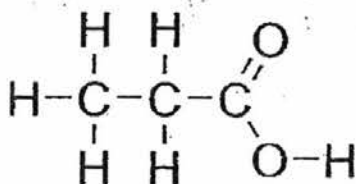
- 8 Food dyes, 1 and 2 are known to contain one or more of three substances X, Y and Z. Two chromatograms are developed; one used water as the solvent, and the other used ethanol. The results are shown in the diagram below.



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 only
 D II and III only
- 9 Element X has 40 nucleons and 19 protons.
 Which of the following represents the **isotope** of X?
- A ${}_{19}^{40}\text{X}$
 B ${}_{19}^{39}\text{X}$
 C ${}_{18}^{40}\text{X}^{+}$
 D ${}_{18}^{39}\text{X}^{+}$
- 10 Which group of elements has the same number of valence electrons?
- A calcium, magnesium, bromine
 B beryllium, barium, strontium
 C potassium, rubidium, calcium
 D sodium, magnesium, aluminium

- 11 Which statement is correct for both diamond and iodine?
- A They conduct electricity.
 B They consist of small molecules.
 C They contain covalent bonds.
 D They have very high melting points.
- 12 Element X has n protons and forms ions with a charge of +2. Element Y has $(n-2)$ protons.
 Which of the following correctly describes X and Y?
- A X reacts with Y to form an ionic compound.
 B X and Y are in the same period of the Periodic Table.
 C The melting point of element Y is higher than that of element X.
 D X can conduct electricity in molten and solid state.
- 13 What is the total number of pairs of electrons shared in a molecule of propanoic acid with the following structure?



- A 10
 B 11
 C 16
 D 22
- 14 Which one of the following is a typical property of transition metals?
- A They burn in air.
 B They form coloured compounds.
 C They have low melting points.
 D They react with cold water to give hydrogen.
- 15 Rubidium is an element in Group I of the Periodic Table. Which one of the following statements about rubidium is **incorrect**?
- A Rubidium has a low density.
 B Rubidium is soft and can be cut with a knife.
 C Rubidium reacts explosively with water to form an alkaline solution.
 D Rubidium is the least reactive metal in the group.

- 16 Acetylene (C_2H_2) is used in welding and it was produced by the reaction shown below. Identify X.

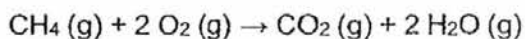


- A CaO
 B Ca_2O
 C CaOH₂
 D $Ca(OH)_2$
- 17 A large sample of hydrated magnesium sulfate ($MgSO_4 \cdot xH_2O$) is heated gently to give anhydrous magnesium sulfate ($M_r = 120$). The table shows some useful data collected from the experiment.

Mass of hydrated magnesium sulfate	384 g
Mass of anhydrous magnesium sulfate	240 g

What is the value of x?

- A 1
 B 2
 C 4
 D 8
- 18 The chemical equation for the complete combustion of methane is as shown below.

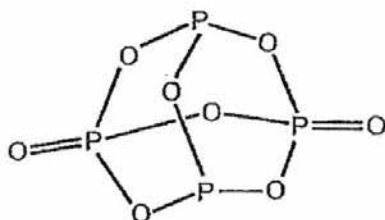


50 cm³ of methane gas is mixed with 40 cm³ of oxygen gas in a sealed vessel and burnt.

What are the volumes of the gases remaining, at the original temperature and pressure?

	Volume of methane/ cm ³	Volume of oxygen/ cm ³	Volume of carbon dioxide/ cm ³	Volume of steam/ cm ³
A	0	0	50	40
B	0	20	20	40
C	30	0	20	40
D	40	40	40	40

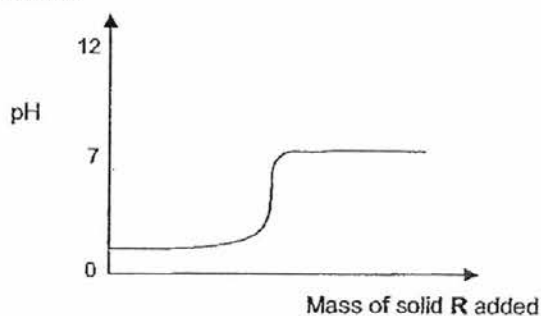
- 19 The structural formula of a molecule is shown in the figure below. Which one of the following shows the correct molecular formula and empirical formula of the molecule?



	Molecular formula	Empirical formula
A	PO ₂	P ₄ O ₈
B	P ₄ O ₆	P ₂ O ₃
C	P ₄ O ₈	PO ₂
D	P ₄ O ₈	P ₂ O ₄

- 20 Which of the following equations best represents the neutralisation reaction between hydrochloric acid and aqueous sodium hydroxide?
- A $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
 B $2\text{H}(\text{g}) + \text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
 C $2\text{H}^+(\text{aq}) + \text{O}^{2-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
 D $\text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{NaCl}(\text{aq})$

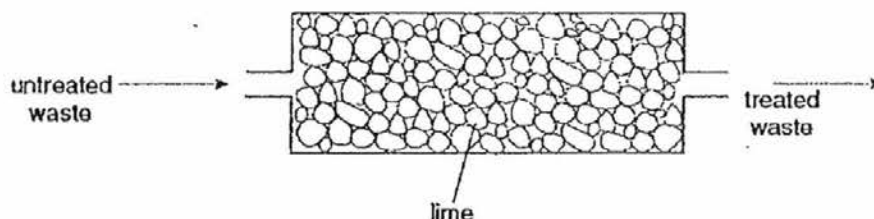
- 21 Solid R is gradually added to aqueous solution S. The changes in pH are shown on the graph below.



What are R and S?

	R	S
A	soluble basic oxide	hydrochloric acid
B	soluble basic oxide	sodium hydroxide
C	insoluble amphoteric oxide	hydrochloric acid
D	insoluble acidic oxide	sodium hydroxide

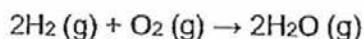
- 22 Lime (CaO) is used to treat industrial waste.



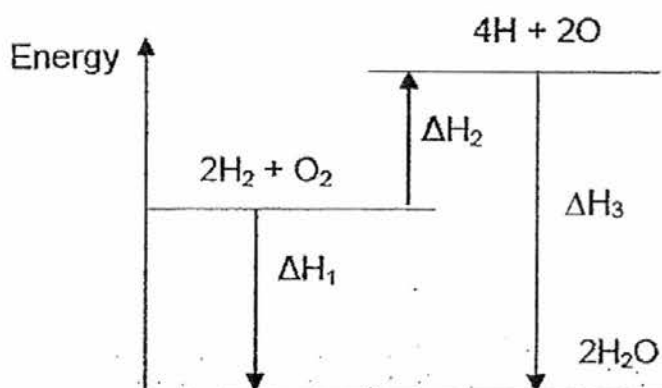
What pH change occurs in the treatment?

- | | <u>untreated waste</u> | → | <u>treated waste</u> |
|---|------------------------|---|----------------------|
| A | acidic | → | neutral |
| B | alkaline | → | acidic |
| C | alkaline | → | neutral |
| D | neutral | → | acidic |
- 23 Which of the following solutions has the lowest pH?
- A 1 mol/dm³ of ethanoic acid
 B 1 mol/dm³ of hydrochloric acid
 C 1 mol/dm³ of sodium chloride
 D 1 mol/dm³ of sodium hydroxide
- 24 John was tasked to identify a bottle of chemical which contained a number of ions. He added aqueous sodium hydroxide into a sample of the solution and observed the following.
- I. Gas evolved upon gentle heating, turned moist red litmus paper blue
 - II. Dirty green precipitate produced, remained insoluble in excess sodium hydroxide
- Which ions can be correctly identified from the observations made?
- A Fe²⁺ and NO₃⁻
 B Fe²⁺ and NH₄⁺
 C Fe³⁺ and NO₃⁻
 D Fe³⁺ and NH₄⁺
- 25 Which of the following is the best pair of reagents to prepare copper(II) sulfate crystals?
- A copper and sulfuric acid.
 B copper(II) carbonate and barium sulfate.
 C copper(II) nitrate and sodium sulfate.
 D copper(II) oxide and sulfuric acid.

- 26 Hydrogen and oxygen react to form steam as in the following equation.



The following energy level diagram represents this reaction.



Which symbols represent the energy involved in bond breaking and formation?

	Energy involved in bond breaking only	Energy involved in bond formation only
A	ΔH_1	ΔH_2
B	ΔH_2	ΔH_3
C	ΔH_2	ΔH_1
D	ΔH_1	ΔH_3

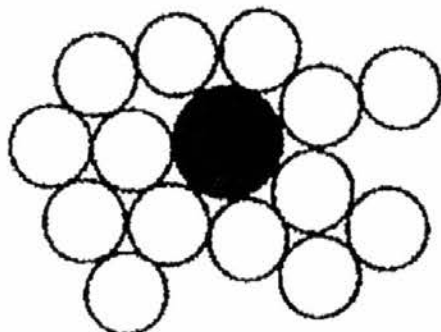
- 27 Which of the following is **not** an exothermic reaction?

- A combustion
- B freezing
- C neutralization
- D photosynthesis

- 28 Which of the following is **not** true of metallic bonding?

- A It gives rise to excellent electrical conductivity.
- B Its strength is indicated by the number of electrons lost.
- C It is the attraction between the metal ions in the metal structure.
- D It is the attraction between the metal ions with the sea of delocalised electrons in the metal structure.

- 29 The structure of brass is shown below.



Why is brass harder than copper?

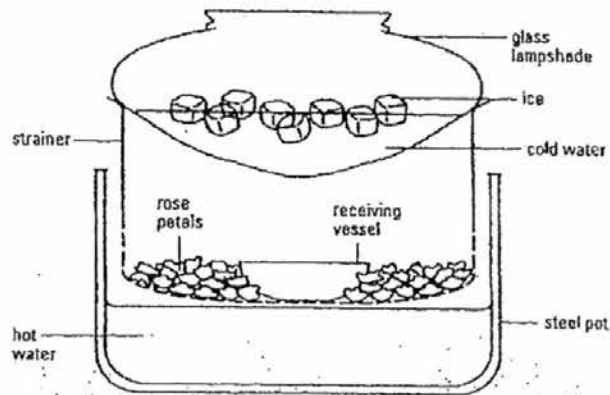
- A The difference in atomic radii of zinc atoms prevent sliding of copper atoms.
 - B The 'sea of electrons' from zinc attract all the atoms together.
 - C The zinc atoms form strong ionic bonds with copper atoms.
 - D The zinc atoms disrupt the atomic structure of copper atoms.
- 30 An element Y reacts with steam to form an oxide. The oxide reacts with aqueous sodium hydroxide to form a salt. It is also able to react with dilute hydrochloric acid to form a salt.

What can element Y be?

- A calcium
- B magnesium
- C sulfur
- D zinc

Section B (40 marks)

- 1 To obtain the fragrant oils used in perfumes, a method called steam distillation is often used. The diagram below shows the apparatus devised by a student. It can be used to obtain fragrant oils found in rose petals.



- (a) Explain why the upper container contains ice and cold water.

.....
 [1]

- (b) Suggest what happens as steam from hot water passes through the rose petals.

.....
 [1]

- (c) Two liquids would be collected in the receiving vessel. Suggest and explain a method to separate these two liquids.

.....
 [2]

2 Some common oxides are shown below.

calcium oxide	carbon monoxide	zinc oxide	nitrogen dioxide
copper(II) oxide	lithium oxide	sulfur dioxide	aluminium oxide

Choose from the list above to identify the following oxides.
Each oxide can be used once, more than once, or not at all.

- (a) An oxide that dissolves in water to form acid rain
..... [1]
- (b) Two oxides that can react with both acids and alkalis
..... [1]
- (c) An oxide that dissolves in water to form a solution of pH 14
..... [1]
- (d) A basic oxide that forms a coloured compound with dilute sulfuric acid
..... [1]
- (e) A gas that does not change the colour of either moist red or blue litmus paper
..... [1]

3 Use the information in the table below to answer the following questions.

Substance	Melting point (°C)	Boiling point (°C)	Electrical conductivity in solid state	Electrical conductivity in molten state
U	-219	-183	poor	poor
V	1085	2562	good	good
W	3727	no data available	poor	poor
X	714	no data available	poor	good
Y	-39	357	good	good
Z	119	445	poor	poor

(a) State and explain which one of the above substance **U**, **V**, **W**, **X**, **Y** or **Z** is

(i) an ionic compound.

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

(ii) a simple covalent molecule.

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

(b) Substance **W** is made of the same element as graphite.

(i) Identify substance **W**.

..... [1]

(ii) Graphite contains covalent bonds and has a melting point similar to that of substance **W**. Explain why the melting point of graphite is significantly higher than that of the substance stated in (a)(ii).

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

- 4 A student investigated an egg shell and tabulated his results as follows.



Test		Observation
1	Dilute hydrochloric acid was added to the egg shell.	<i>Observations 1 and 2</i>
2	Sodium hydroxide solution was added to the colourless solution from test 1.	A white precipitate formed that did not dissolve in excess sodium hydroxide solution.
3	Silver nitrate solution was added to the colourless solution from test 1.	A white precipitate formed.

- (a) The student concluded that the egg shell contains carbonate ions. What should the observations 1 and 2 for Test 1 be?

.....
 [2]

- (b) The student concluded that the egg shell contains aluminium ions. Is the student's conclusion correct? Use the student's results to justify your answer.

.....

 [1]

- (c) (i) State the identity of the white precipitate in Test 3.

..... [1]

- (ii) The student concluded from the Test 3's result of the presence of chloride ions. Explain why the result is inconclusive.

.....
 [1]

- 5 Magnesium sulfate is found in Epsom salts that are used to soothe sore muscles in athletes. Sulfuric acid and magnesium oxide are used to make magnesium sulfate.

(a) Write the chemical equation, with state symbols, for the above reaction.

..... [2]

(b) Describe the experimental steps required to produce a dry sample of magnesium sulfate.

.....
.....
.....
.....
.....
.....
.....
..... [3]

(c) Magnesium carbonate is another salt that can be indirectly prepared from sulfuric acid. State the steps and the chemicals required to prepare magnesium carbonate from sulfuric acid.

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

- 6 The space ship, Zurit, landed as an analytical laboratory on Mars in 2012. The laboratory contained equipment which can determine the percentage of elements in a rock sample.

The percentage by mass of compound Z, determined using this type of equipment is given below:

element	percentage by mass
potassium	39.3
iron	28.3
oxygen	32.3

- (a) Show that the empirical formula of Z is K_2FeO_4 .

[2]

- (b) K_2FeO_4 can be prepared in the laboratory by the reaction between iron(III) oxide, chlorine and potassium hydroxide.

- (i) Balance the chemical equation by filling in the blanks.



- (ii) A 2.00 g sample of Fe_2O_3 is added to 20.0 cm³ of 4.00 mol/dm³ KOH.

Find the limiting reagent for the reaction.

[2]

- (iii) Find the mass of K_2FeO_4 formed.

[1]

- 7 A new element called 'Delium' has been isolated. It has a low melting point and density. It is extremely reactive in air. It is also a good conductor of electricity. It has a chemical symbol of **De**.

- (a) Which group does this new element belong to?

[1]

- (b) Write a chemical equation, with state symbols, when Delium is placed in cold water.

[2]

- (c) Describe what will be observed if a few drops of Universal indicator was added into the cold water.

[1]

- (d) With reference to the bonding and structure of Delium, explain why Delium is a good conductor of electricity.

[2]

Section C (30 marks)

Answer all **three** questions, the last question is in the form of either / or.

- 1 Read the information about properties of some of the metals found in the Periodic Table. The letters below does not represent the symbol of the metals in the Periodic Table. The initial temperature for the reaction is 30 °C.

Metal	Observation for the reaction of metal with dilute hydrochloric acid	Maximum Temperature reached/ °C
D	no bubbles at all	30
E	bubbling	42
G	slow bubbling	34
J	very vigorous bubbling	82
L	rapid bubbling	64
M	very few bubbles initially followed by steady bubbling	58

Metal	Density/ kgm ⁻³	Melting points/ °C	Atomic Radius/pm	Possible oxidation state(s) when it forms compound
D	10490	961	165	+1
E	7470	1246	161	+2, +3, +4, +6, +7
G	7140	419	142	+2
J	968	98	190	+1
L	1550	842	194	+2
M	1738	650	145	+3

Note: Density of water is 1000 kgm⁻³

- (a) Using information from the table, explain if the reaction of metals with hydrochloric acid is an exothermic or endothermic reaction.

.....

[2]

- (b) Arrange in decreasing order, the relative reactivity of the metals, starting with the most reactive metal. Explain how you derived at this answer.

.....

 [2]

- (c) Explain the observation when metal **M** reacted with dilute hydrochloric acid.

.....

 [2]

- (d) A student attempts to identify a transition metal from the table. Explain which is the most suitable metal.

.....
 [2]

- (e) Write a chemical equation, with state symbols, for the reaction between metal **J** with cold water.

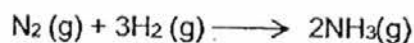
..... [2]

- 2 The following is an abstract from the Internet.

Nitrogen is an **element** with a melting point of $-210\text{ }^{\circ}\text{C}$ and boiling point of $-186\text{ }^{\circ}\text{C}$. Nitrogen is a colourless, odourless, tasteless and mostly inert diatomic gas at standard conditions. The extremely strong bond in nitrogen dominates nitrogen chemistry, causing difficulty for both organisms and industry in breaking the bond to convert the nitrogen into useful **compounds**. However, when these compounds burn, explode, or decay back into nitrogen gas they release large amounts of often useful energy.

- (a) Draw the electronic structure of nitrogen molecule, showing only the valence electrons.

- (b) Nitrogen reacts with hydrogen under optimum reacting conditions to form ammonia gas in the Haber Process. The equation is given below.



The table below states the different bond energies.

bond	energy (kJ/mol)
H-H	432
N-H	386
N=N	420
N≡N	940

Using the data provided in the table, calculate:

- (i) the total energy change for bond breaking.

[1]

- (ii) the total energy change for bond formation.

[1]

- (iii) the overall energy change of the reaction, ΔH .

[1]

- (iv) Hence, explain in terms of bond breaking and bond formation, if the Haber process is an endothermic or exothermic process.

.....

.....

.....

[2]

- (c) Draw a labeled energy profile diagram for the process of the Haber Process.

Indicate clearly on the diagram, the activation energy for the reaction with the symbol, E_a , the reactants and products, and ΔH of the reaction.

[3]

Either

- 3 The following table shows the preferred pH in which some crops grow best.

plant	apple	potato	blackcurrant	mint	onion	lettuce
pH	5.0 – 6.5	4.5 – 6.0	6.0 – 8.0	7.0 – 8.0	6.0 – 7.0	6.0 – 7.0

- (a) Apples grow best in weakly acidic soil. Explain what it means by the term 'weak acid'.

.....

- (b) (i) A farmer needs to treat the soil prior to replacing his potato plants with mint plants. Suggest and explain how the farmer can treat the soil to grow mint plants.

..... [2]

.....

.....

..... [2]

- (ii) Explain why the farmer should not add fertilisers such as ammonium nitrate to the treated soil.
Support your answer using a chemical equation.

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

- (c) An acid has the formula H_2XO_4 . A solution of the acid contains 5.0 g/dm^3 of H_2XO_4 . In a titration, 25.0 cm^3 of the acid reacted with 25.5 cm^3 of 0.1 mol/dm^3 KOH solution.

- (i) Given that the reacting mole ratio of $\text{H}_2\text{XO}_4 : \text{KOH} = 1 : 2$, find the number of moles of H_2XO_4 used.

[2]

- (ii) Hence, find the identity of X.

[2]

Or
3

The table gives some properties of the elements in Group VII. The properties for astatine are missing in the table.

element	melting point/ °C	boiling point/ °C	atomic radius/ pm
fluorine	-220	-188	64
chlorine	-101	-35	99
bromine	-7	59	114
iodine	113	183	133
astatine			

- (a) Which halogen is a liquid at room temperature and pressure?
..... [1]
- (b) Explain why astatine is in the same group as fluorine and bromine.
..... [1]
- (c) Describe the trend of melting point of the halogens. Hence, predict the melting point of astatine.
..... [2]
- (d) Describe the trend of another physical property that is not listed in the table.
..... [1]
- (e) Predict the molecular formula of astatine.
..... [1]
- (f) Chlorine gas was bubbled into a beaker containing aqueous potassium iodide.
- (i) Write the chemical equation, with state symbols, to represent the reaction.
..... [2]
- (ii) Explain why the reaction takes place.
..... [2]

~ End of Paper ~

The Periodic Table of the Elements

		Group																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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7	Li lithium 3	9	Be beryllium 4	11	B boron 5	12	C carbon 6	13	14	15	16	17	18	20	Ne neon 10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
23	Na sodium 11	24	Mg magnesium 12	27	Al aluminum 13	28	Si silicon 14	29	30	31	32	33	34	35	36	Ar argon 18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
39	K potassium 19	40	Ca calcium 20	45	Sc scandium 21	48	Ti titanium 22	51	52	55	56	59	60	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
85	Rb rubidium 37	88	Sr strontium 38	89	Y yttrium 39	91	Zr zirconium 40	93	Nb niobium 41	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000

*58-71 Lanthanoid series
†90-103 Actinoid series

Key

a	X
b	

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

140	Ce cerium 58	141	Pr praseodymium 59	144	Nd neodymium 60	145	Pm promethium 61	150	Sm samarium 62	151	Eu europium 63	152	Gd gadolinium 64	157	Tb terbium 65	158	Dy dysprosium 66	162	Ho holmium 67	164	Er erbium 68	165	Tm thulium 69	167	Yb ytterbium 70	173	Lu lutetium 71
90	Th thorium 90	91	Pa protactinium 91	92	U uranium 92	93	Np neptunium 93	94	Pu plutonium 94	95	Am americium 95	96	Cm curium 96	97	Bk berkelium 97	98	Cf californium 98	99	Es einsteinium 99	100	Fm fermium 100	101	Md mendelevium 101	102	No nobelium 102	103	Lr lawrencium 103

End-Of-Year Examination 2016
Sec 3E
Pure Chemistry
Answers / Mark Scheme

Section A(30m)

1	2	3	4	5	6	7	8	9	10
A	D	B	D	D	B	C	C	B	B
11	12	13	14	15	16	17	18	19	20
C	D	B	B	D	D	C	C	C	A
21	22	23	24	25	26	27	28	29	30
C	A	B	B	D	B	D	C	A	D

Section B (40 m)

1(a)	To condense the oil vapour so that the fragrant oils can be collected in the receiving vessel.	1
(b)	As steam passes through the rose petals, the oil from the rose petals vapourises / evaporates .	1
(c)	Use separating funnel.	1
	Two liquids (Fragrant oils and water) collected are immiscible / Two liquids collected have different density .	1
Total:		4m
Marker's report:		
(a) Question is generally well done. Students need to remember that the focus is to condense the oil vapour and not the water vapour.		
(b) Some wrong terms are used such as 'diffuses' or 'picks up the scent'. Shows that students are not sure what the vapour.		
(c) Many students state the method used as 'fractional distillation' as they wrongly identified that oil and water are miscible liquids with different boiling point. They should note that oil and water are immiscible liquids.		

2(a)	sulfur dioxide / nitrogen dioxide	1
(b)	zinc oxide and aluminium oxide	1
(c)	lithium oxide	1
(d)	copper(II) oxide	1
(e)	carbon monoxide	1
Total:		5m

	Marker's report: Generally not very well done. Students are not familiar with the different properties of the oxides and have not correctly identified with the different examples of oxides, i.e. acidic, amphoteric, neutral, basic oxides	
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3(a)(i)	X It has high melting point and boiling point and conducts electricity in molten but not solid state. (no marks if substance wrongly identified)	1 1
(a)(ii)	Z or U. It has low melting and boiling point and does not conduct electricity. (no marks if substance wrongly identified)	1 1
(b)(i)	diamond	1
(b)(ii)	More energy is needed to break the strong covalent bonds between carbon atoms in graphite than; to overcome the weak intermolecular forces between molecules in substance Z.	1 1
Total:		7m
	Marker's report: (a) Students need to use the data from the table provided to answer the question. However, many did not fulfil this. There is no need to explain the properties. Some students stated the one property and not the other (b) Most were able to correctly identify diamond. For b(ii), it was rather poorly done. Key words such as break strong covalent bonds between carbon atoms and overcome weak van der Waal's forces between molecules are not stated. Some students used the key words 'break' and 'overcome' very loosely. Some students were clearly unsure of the type of bonding present in graphite or simple covalent molecule.	

4 (a)	Effervescence observed. The egg shell dissolved, forming a colourless solution / white precipitate is observed when the gas is bubbled into limewater.	1 1
(b)	No. If aluminium ions are present, they should form white precipitate which dissolves in excess sodium hydroxide solution to form a colourless solution in Test 2.	1
(c)(i)	silver chloride	1
(ii)	Chloride ions (Cl ⁻) present due to hydrochloric acid added in from Test 1.	1
Total:		5m
	Marker's report: (a) Many students are not able to state the second observation that the egg shell dissolved to form a colourless solution. Stating that 'water	

	<p>and carbon dioxide produced' is not an observation as it cannot be seen.</p> <p>(b) Some students state that aluminium ions dissolve in excess sodium hydroxide. Note that it is the precipitate formed that dissolves. Not aluminum ions.</p> <p>(c) Only half of the cohort managed to identify correctly.</p> <p>(d) Students were not able to draw the link from test 1 that the hydrochloric acid added could have contributed to the presence of chloride ions in the solution.</p>	
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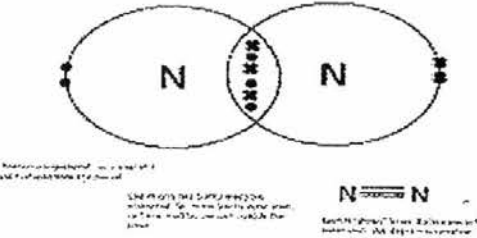
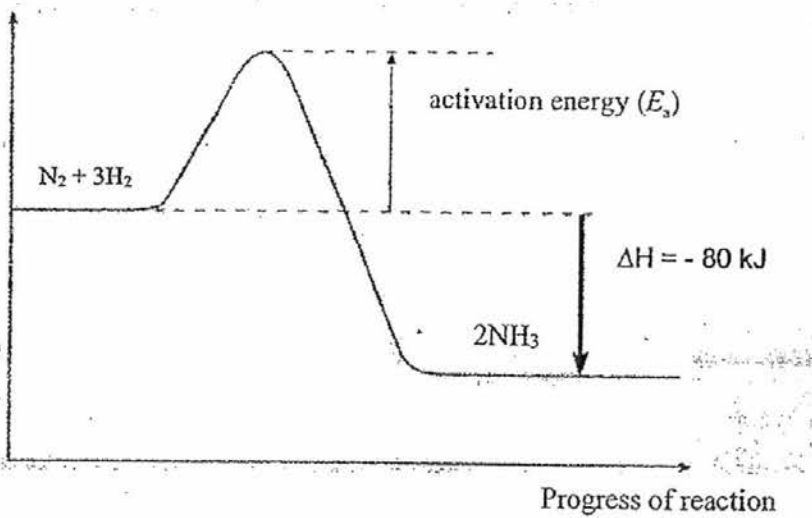
5(a)	$\text{MgO(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{MgSO}_4(\text{aq}) + \text{H}_2\text{O(l)}$ <p>1m for balanced equation 1m for state symbols 0 marks given if BCE is not attained.</p>	2
(b)	<ul style="list-style-type: none"> • add magnesium oxide to sulfuric acid and <u>stir</u> • add the solid until it is <u>in excess</u> • <u>filter</u> and collect the <u>magnesium sulfate as filtrate</u> • <u>heat</u> the filtrate until it is <u>saturated</u> • let it <u>cool</u> and wait for <u>crystals to form</u> • <u>wash</u> crystals with small amount of <u>distilled water</u> • <u>dry</u> crystals between sheets of <u>filter paper</u> <p>all 7 pts – 3 m 5-6 pts - 2 m 3-4 pts - 1 m</p>	3
(c)	<p>Add magnesium / magnesium oxide / magnesium hydroxide to sulfuric acid;</p> <p>Then add potassium carbonate / sodium carbonate / ammonium carbonate/carbonic acid</p> <p>1m for just listing correct chemicals</p>	1 1
Total:		7m
	<p>(a) Most candidates are able to give the balanced chemical equation, some forget to include state symbols.</p> <p>(b) Candidates are supposed to use MgO and H₂SO₄, MgO should be in excess. MgSO₄ produced is filtered and collected as filtrate. Marks are still awarded for describing correctly the ways of obtaining the dry salt.</p> <p>(c) Majority of the candidates found difficulty in answering this question. They are supposed to make MgCO₃ using sulfuric acid as one of the starting reactant. This requires them to do 2 steps. Acid + insoluble excess to obtain MgSO₄ and then ppt to form the insoluble MgCO₃.</p>	

6 (a)		K	Fe	O
	Mass	39.4	28.3	32.3
	Ar	39	56	16

	<table border="1"> <tr> <td>No of moles</td> <td>$\frac{39.4}{39} = 1$</td> <td>$\frac{28.3}{56} = 0.5035$</td> <td>$\frac{32.3}{16} = 2.018$</td> <td rowspan="3">1</td> </tr> <tr> <td>Divide by smallest no</td> <td>$\frac{1}{0.5035}$</td> <td>$\frac{0.5035}{0.5035}$</td> <td>$\frac{2.018}{0.5035}$</td> </tr> <tr> <td>Ratio</td> <td>2</td> <td>1</td> <td>4</td> </tr> </table>	No of moles	$\frac{39.4}{39} = 1$	$\frac{28.3}{56} = 0.5035$	$\frac{32.3}{16} = 2.018$	1	Divide by smallest no	$\frac{1}{0.5035}$	$\frac{0.5035}{0.5035}$	$\frac{2.018}{0.5035}$	Ratio	2	1	4	1
No of moles	$\frac{39.4}{39} = 1$	$\frac{28.3}{56} = 0.5035$	$\frac{32.3}{16} = 2.018$	1											
Divide by smallest no	$\frac{1}{0.5035}$	$\frac{0.5035}{0.5035}$	$\frac{2.018}{0.5035}$												
Ratio	2	1	4												
	<p>Reject if round off at number of moles (minus 1m) No working shown (minus 1m)</p>														
(b)(i)	$\text{Fe}_2\text{O}_3 + 3\text{Cl}_2 + 10\text{KOH} \rightarrow 2\text{K}_2\text{FeO}_4 + 6\text{KCl} + 5\text{H}_2\text{O}$	1													
(b)(ii)	<p>No of moles of $\text{Fe}_2\text{O}_3 = \frac{2}{2(56) + 3(16)} = 0.0125 \text{ mol}$</p> <p>No of moles of $\text{KOH} = \frac{20}{1000} \times 4 = 0.08 \text{ mol}$</p> <p>1 m for both no of moles</p> <p>Based on mole ratio $\text{Fe}_2\text{O}_3 : \text{KOH}$ 1 : 10 0.0125 : 0.125</p> <p>But there are only 0.08 mol of KOH, hence KOH is the limiting reactant</p> <p>ecf 1m for stating LR correctly based on how b(i) equation was balanced.</p>	1													
(b)(iii)	<p>Mass of $\text{K}_2\text{FeO}_4 = 0.016 \times [2(39) + 56 + 4(16)]$ $= 0.016 \times 198$ $= 3.17 \text{ g}$</p> <p>no units/ not in 3sf zero marks/no ecf</p>	1													
	Total:	6m													
	<p>(a) Generally well done. Except some failed to present working.</p> <p>(b) (i) Only a few of the candidates were able to balance the equation correctly.</p> <p>(ii) Majority of the candidates did not attempt, however, they should be able to calculate the amount of the reactants even though they do not know how to balance the equation.</p> <p>ecf 1m was given for proofing their LR correctly based on their equation and amount of reactants.</p> <p>(iii) Majority of the candidates used correct formula but failed to give their answers in 3sf.</p>														
7 (a)	Group I	1													

(b)	$2\text{De (s)} + 2\text{H}_2\text{O (l)} \rightarrow 2\text{DeOH (aq)} + \text{H}_2 \text{(g)}$ 1m – correct balanced equation 1m – state symbols 0 marks given if BCE is not attained.	2
(c)	The solution will turn violet / purple in colour. Rej: Blue	1
(d)	Delium has a <u>giant metallic structure / giant lattice structure</u> , with a <u>sea of mobile delocalised electrons</u> to conduct electricity. Accepted : metallic bonding/metals (for this round)	1 1
Total:		6m
	(a) Generally well done (b) Many candidates either did not balance the equation or wrote De_2O , they failed to see that the reaction is with COLD WATER. (c) The alkali formed is a strong alkali, because De is Group I hence it should be violet/purple. Some candidates mentioned the colour as blue. (d) Majority of the candidates did not use structure/bonding to answer the question, some failed to use the keywords 'delocalised'. Metals do not use cations in conducting electricity.	

Section C (30 m)		
1(a)	exothermic there is an increase in temperature / a rise in temperature measured. Rej: heat given out.	1 1
1(b)	J, L, M, E, G, D The most reactive metal will react with hydrochloric acid to give the largest temperature rise / result in the highest maximum temperature reached. The next reactive metal will give a smaller temperature rise. Rej: more reactive more bubbling.	1 1
1(c)	M has a layer of oxide surrounding the metal. The acid reacts with some part of the metal exposed to produce hydrogen gas , thus very few bubbles observed. After all the oxide layer has reacted , the metal reacts vigorously with the acid to produce steady bubbling of hydrogen gas.	1 1
1(d)	E The metal has variable oxidation states .	1 1
1(e)	$2J (s) + 2H_2O (l) \rightarrow 2JOH (aq) + H_2 (g)$ 1m for balanced chemical equation. 1m for correct state symbols. 0 marks given if BCE is not attained.	2
Total:		10m
<p>(a) Some candidates mentioned the increased in temperature but relate it the reaction as 'endothermic'. Candidates need to use information from the table to answer why it is an exothermic reaction, the table only provided information on temperature rise and not 'heat' energy.</p> <p>(b) Some candidates mixed up the reactivity of M and E. Majority of the candidates failed to relate metal reactivity to temperature rise but relate it to the bubbling. However, vigorously bubbling does not necessary means a reactive metal.</p> <p>(c) Majority of the candidates are able to mention the protective layer, but they failed to explain the latter observation of why the bubbling increases.</p> <p>(d) Some candidates mentioned G or E for their high melting point or density, but variable oxidation states is unique to transition metals.</p> <p>(e) Some candidates used their own metal formula instead of 'J' or gave J_2O as the product. Reaction is metal with cold water.</p>		

2(a)	<p style="text-align: center;">Nitrogen N₂</p>  <p>1m – correct number of electrons shared (3 pairs in the correct manner) 1m – different symbols of electrons used (dot and cross)</p>	2
2(b)(i)	<p>Total energy change for bond breaking = $3(432) + 940$ = +2236kJ</p>	1
(ii)	<p>Total energy change for bond formation = $2(3(386))$ = - 2316kJ</p>	1
(iii)	<p>Overall energy change, $\Delta H = +2236\text{kJ} - 2316\text{kJ}$ = -80kJ</p>	1
(iv)	<p>Since the amount of energy <u>released</u> in forming the N-H bonds is <u>greater</u> than the energy <u>absorbed</u> for breaking the N≡N and H-H bonds, therefore the Haber Process is an <u>exothermic</u> reaction.</p>	1 1
	<p>Energy / KJ</p>  <p>Progress of reaction</p> <p>1m – shape of graph i.e. exothermic graph 1m – labels on x and y axes 1m – labels of reactants, products, Ea and ΔH (correct directions of arrows)</p>	3

	<p>(a) Many students did not draw dot and cross for nitrogen molecule. Many drew just dot or cross for both N atoms. Some did not show 3 pairs of dot & cross in the overlapping space between both N atoms. Some did not understand the question and drew N's electronic structure.</p> <p>(b) For 2b(i) to 2b(iii), if students did not write the sign "+" or "-", overall 1m is deducted. For 2b(i) to 2b(iii), if students did not write the correct unit/missing unit, overall 1m is deducted. This time round, those students who wrote statements for 2b(i) and 2b(ii) as energy released and energy absorbed, were not penalised for the omitting of sign.</p> <p>(b)(iv) Very badly done as many students kept using words "energy used/required/ needed etc"</p> <p>(c) Energy profile diagram was also badly drawn as axes was not correctly labelled. Often, x-axis was labelled as process of reaction, time, etc. The direction of arrows was also not clear as many students drew double-headed arrows.</p>	
	Total:	10m

Either

3(a)	Weak acid partially dissociates / ionises in water to give a low concentration of hydrogen ions .	1 1
3(b)(i)	Slaked lime, Ca(OH) ₂ or quicklime, CaO	1
	Addition of the above substances will <u>increase the pH / neutralise acid</u> so that it's suitable for growth of mint plant.	1
(ii)	The essential <u>ammonium/nitrogen</u> in fertilisers <u>will be lost as</u> the ammonium salts in fertilisers will react with the alkali (calcium hydroxide) to liberate <u>ammonia gas</u> .	1
	$2\text{NH}_4\text{NO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{Ca}(\text{NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NH}_3$	1
3(c)(i)	No. of moles of KOH = $(25.5/1000) \times 0.1$ = 0.00255 mol	1
	No. of moles of H ₂ XO ₄ = $0.00255 / 2$ = 0.001275 mol	1
	Answer + unit: 1 mark	
(ii)	Concentration of H ₂ XO ₄ = $0.001275 / (25.0/1000)$ = 0.051 mol/dm ³	1
	Relative molecular mass of H ₂ XO ₄ = $5.0 / 0.051$ = 98.0 (3 s.f.)	
	X is sulfur. Answer + unit: 1 mark	1
	<p>(a) Many students omit the 2nd point to "form a low concentration of hydrogen ions".</p> <p>(b)(i) Some students just state that an alkali should be added to neutralize the acid, but did not suggest a suitable alkali.</p> <p>(b)(ii) Very poorly done by the students who attempted. They did not seem to understand ammonia gas will be liberated.</p> <p>(c)(i) and (c)(ii) It was well done by the students who chose this question.</p>	

	Total: 10m
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Or

3(a)	bromine	1
(b)	Astatine has the same number of valence electrons as fluorine and bromine	1
(c)	The melting point of halogens increases down the group. Accept: 220 °C – 235 °C	1 1
(d)	The halogens become darker down the group.	1
(e)	At ₂	1
(f)(i)	Cl ₂ (g) + 2KI (aq) → 2KCl (aq) + I ₂ (aq) 1m for correct balanced chemical equation 1m for correct state symbols	2
(f)(ii)	The more reactive chlorine displaces the less reactive iodine from potassium iodide solution.	1 1
	(a) Well done by the students. (b) Some students wrote that the astatine will form an ion with -1 charge. Fundamentally not wrong, but did not answer the question directly of why will astatine form an ion with -1 charge? It was because Astatine has 7 valence electrons. In order to achieve a stable electronic configuration, it needs to gain 1 more electron to form an ion with -1 charge. (c) Many students did not attempt the melting point, or gave answers out of range. Some even left out units. (d) Density, change from gas to liquid to solid state as they go down the group etc, were all accepted. However, reactivity is not accepted. (e) Some students did not read the question and wrote as At ⁻ (f) I ₂ (aq) should be the correct answer. I ₂ (s) is given this time round as the notes given to the students was having an error. (f)(ii) Most students confused "displaced" and "replaced". They also often left out the 2 nd portion explaining where the less reactive iodine is found.	
	Total: 10m	

Marker's report for 5073	
S/No.	Remarks
	Section B
1	Most of the pupils can do part (a). A few pupils left blank and can only obtain ammonia gas. Some pupils thought the cation of A should be transition metals like Zinc/Lead. But, the fact that the compound can react to give 2 gases suggest it contains ammonium and carbonate! Most of the pupils can do part (b).
2	Parts (a)–(c) are quite well done. A few pupils drew the band 1 / 2 incorrectly and one drew many spots on the chromatogram. Quite a number of pupils did not answer Part (d) accurately. Common incorrect solutions include: "prevent air / wind from entering", "prevent contamination" etc.
3	Parts (a)–(d) are generally well done. A handful of pupils gave the suggested timing of N ₂ WITHOUT OBSERVING that the timing for N ₂ should be the same as CO.
4	Part (a)–(b) are generally well done. For part (a), pupils who didn't get it correct fail to illustrate the surrounding ions of Na ⁺ by Cl ⁻ to be 6 and Cl ⁻ by Na ⁺ to be 6 too. Hence, some drew on wrong plane. For part (b), some pupils did not read the instructions carefully and added more planes despite instructions given "one layer of graphite". This resulted in higher chance of mistakes as the number of bonds around each C atom is 3 instead of 2. Part (d) is averagely attempted. There are 2 parts to this question: soft and electrical conductivity. For soft, pupils need to mention the weak intermolecular forces of attraction BETWEEN layers hence layers can slide. Incorrect phrasing include "weak covalent bonds", sliding between atoms", "Weak intermolecular between atoms" as well as due to "weak intermolecular forces of attraction, melting point is low"! For the electrical conductivity, pupils need to mention unbonded electron (also known as free) and electron is delocalised.
5	Part (ai) is well attempted. For part (a(ii)), the reason for redox is very general. Pupils should anchor the explanation that o.s of silver in AgNO ₃ and AgBr is +1 while the o.s of bromine in KBr and AgBr is -1. However, because the reason is NOT redox, a general explanation is accepted due to leniency. Part (b) is averagely answered. Silver ion in silver bromide or silver bromide. Pupils should learn to view the REACTANTS so as to eradicate the chances of writing any substances in the products!!!!
6	Part (a) is poorly attempted. Pupils forgot to use reversible arrows ⇌ Part (b) is averagely attempted. The definition of reversible reaction is poorly presented. Part (c) is generally well done. Part (d) is averagely attempted. pupils should give answers from the graph and relate that at 550°C, the yield is much lesser than at 450°C.
7	Part (a) is generally well done. Marks are deducted due to missing plotting of points. Part (b) is generally well done. For the elegant presentation of answers, pupils need to have an APPARATUS to contain the gas. Some phrases are rejected: "into the gas" etc.

	<p>Part (c) is badly done. Pupils need to be able to observe Zinc is more reactive than Copper. Instead, a lot of pupils proposed equations that merely result as mixture of ions: $\text{CuSO}_4 + \text{ZnCl}_2 \rightarrow \text{CuCl}_2 + \text{ZnSO}_4$</p> <p>Part (d) is averagely done. Pupils need to add excess solid to dilute acid.</p>
	Section C
8	<p>Part (ai) is self attempted. Part (a ii) is badly attempted. Pupils did not explain WHY due to insufficient oxygen, it is not suitable for mankind. Most quote phrases such as " due to shortage of oxygen, it is unsuitable for mankind to live in " (pupils copy from the question), " oxygen is essential" (why is it essential?) ". Pupils need to give reasons: for breathing/respiration/support lives.</p> <p>For the factor of hydrogen, it is well done.</p> <p>Part (b)-(d) are well done.</p> <p>Part (e) is poorly attempted. Pupils should think about what will happened if the substances existed at extreme temperature \rightarrow they will exist in vapour state and it is constantly moving.</p> <p>Answers that there are no instrument / too hot to do estimation is incorrect.</p>
9	<p>Part (a) generally well done. Part (b) Only Manganese / Chromium can be accepted. Some pupils gave transition metals that does not exist as charges of 6+</p> <p>Part (c) is badly done. Most pupils overlook if the metals are from group I, the products are ALKALIS.</p> <p>Part (di) generally well done.</p> <p>Part (dii) is poorly attempted. The concept of displacement of less reactive halogen from AQUEOUS solution is poorly demonstrated. Hence pupils can displace from oxides of halogen instead. Yet the conditions are not favourable. Pupils need to know that for DESIGN experiment, they do not need to make the chemicals from scratch. The starting materials can be aqueous solution of halogen! The equation writing is horrifying because the halogen J or L became MONATOMIC instead of DIATOMIC.</p> <p>Pupils lose 1 mark in average for this design experiment because they assumed that if they react J_2 with NaL is conclusive. It is the standard procedures for scientist to do the same reaction with L_2 using NaJ.</p>
10	<p>Part (a) is generally well done. A few pupils drew it incorrectly either using the mass number or the compound is not electronically stable. Part (b) is generally well done. Pupils need to remember that Upwards arrow is used for E_a and not both directions.</p> <p>Part (bi) is averagely attempted. Pupils need to use the results from the graph. Hence answers : heat energy is absorbed" is not accepted.</p> <p>Part (ci) is averagely attempted. Pupils either rank the MOST reactive first or swop the position of H and G.</p> <p>Part (bii) is generally well attempted.</p> <p>Part (ciii) is averagely attempted. Pupils thought the reaction need to be extraction using CO. This trend of thought is short-sighted. Question requested for reaction with Coke (C). Pupils can give either CO_2 or CO. But the most favourable reaction should target to have CO_2 as product.</p>