CHIJ ST JOSEPH'S CONVENT
SEMESTRAL ASSESSMENT 2

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CHEMISTRY (SPA) 5073

Secondary 3 Express

Thurs, 6 October 2016
2 hours

Candidates answer on the Question Paper.
Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your index number, class and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you considered correct and record your choice in **soft pencil** on the separate Answer Sheet. Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Section B
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section C
Answer all questions.
Write your answers in the spaces provided on the question paper.

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

A copy of the Periodic Table is printed on page 29.

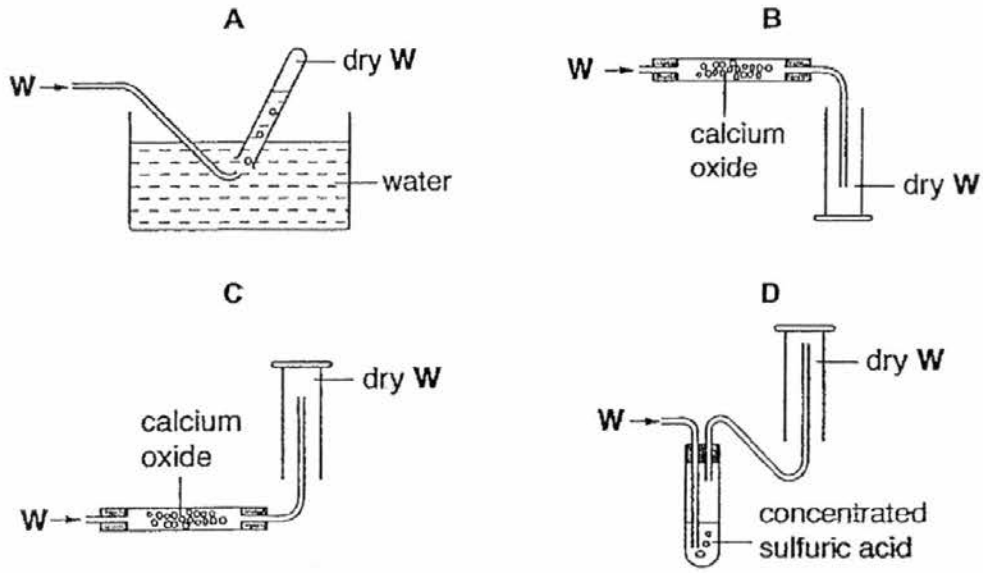
FOR EXAMINER'S USE	
A	
B	
C	
Total	100

This document consists of **29** printed pages.

Setter(s): Mr. Jansen Tan and Mrs. Stella Tan

Section A (30 marks)
Answer **all** questions.

1 Gas **W** (M_r = 17), is very soluble in water and is alkaline. Which method is used to collect a dry sample of Gas **W**?



2 When fine pollen grains are suspended in water and viewed through a microscope, the pollen grains appear to move in random fashion.

This motion is the result of

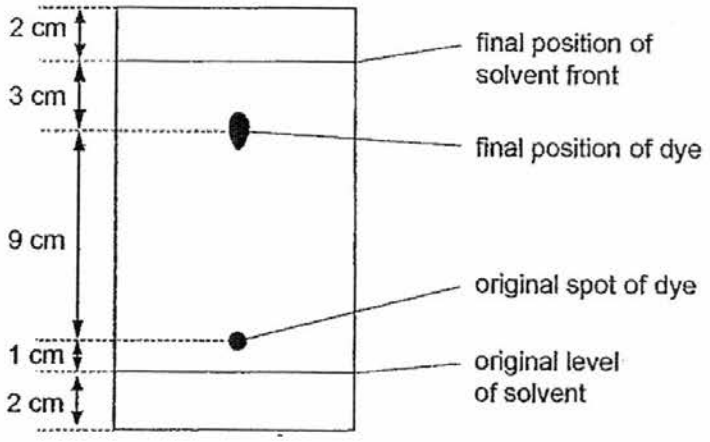
A currents in the water.
B pollen gains slowly dissolving in the water.
C bombardment of pollen grains by water molecules.
D the pollen grains moving in constant and random motion in all directions.

3 A mixture contains three solids, ammonium chloride, magnesium chloride and silver chloride.

In what order should the processes be carried out to ensure effective separation of each component from the mixture?

A dissolution → filtration → sublimation → crystallisation
B dissolution → filtration → crystallisation → sublimation
C sublimation → dissolution → filtration → crystallisation
D sublimation → dissolution → crystallisation → filtration

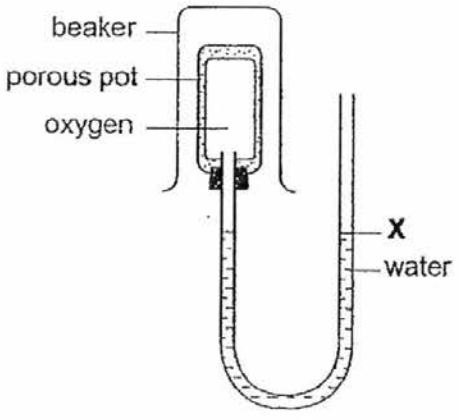
4 The diagram shows the chromatogram obtained by analysis of a single dye.



What is the R_f value of the dye?

A 0.71
B 0.75
C 0.77
D 0.80

5 The apparatus is set up as shown below. Oxygen gas is present initially in the porous pot and the water level was stationary at **X**. Different gases are then added to the beaker separately.



Which gas, when present in the beaker, causes the water level at **X** to rise?

A nitrogen dioxide
B carbon dioxide
C methane
D chlorine

6 A sample of solid **X** melts gradually over a large range of temperatures. However, the liquid that is formed on heating solid **X** solidifies at one temperature. This sample contains most likely

A a pure compound.
B a mixture of compounds miscible in the liquid state.
C a mixture of compounds immiscible in the liquid state.
D a mixture of two compounds that combine to form a new compound when fused.

7 The melting point and boiling point of substance **E** are –32°C and –8°C respectively. Which of the following statements concerning the particles in **E** is **true**?

A At –4 °C, the size of the particles decrease.
B At –20 °C, the particles possess the greatest amount of kinetic energy.
C At –33 °C, the attractive forces between the particles are the strongest.
D At –31 °C, the particles are packed closely together and orderly arranged.

8 Which is the same for the particles ^{40}Ar and $^{39}K^{+}$?

A the number of electrons
B the number of nucleons
C the number of protons
D the number of neutrons

9 Carbon has isotopes with relative atomic masses of 12, 13 and 14.

If ethene, C_2H_4, is formed from these carbon isotopes, which of the following is **not** a possible relative molecular mass of ethene?

A 30
B 31
C 32
D 33

10 A solid **X** which does not conduct electricity at room temperature and has a very high melting point.

Which of the following statement(s) are possible inferences?

I **X** could have a giant ionic lattice structure.
II **X** could have a giant covalent structure.
III **X** could have a giant metallic structure.

A I and II only
B I and III only
C II and III only
D All of the above

11 Metals have positive ions in a 'sea of electrons'. Which metal atom provides the most electrons for the sea?

A aluminium
B sodium
C calcium
D magnesium

12 The table shows four elements, **W**, **X**, **Y** and **Z** with their atomic numbers.

element	W	X	Y	Z
atomic number	6	9	11	17

What are the likely formulae of ionic compound and covalent compound formed from the four elements above?

	formula of ionic compound	formula of covalent compound
A	WX	YZ
B	Y_2X	WX_2
C	YZ	WZ_4
D	YW	ZX

13 In a laboratory accident, a bottle containing concentrated hydrochloric acid was knocked over and its contents was spilt on the floor.

What is the best method to deal with this chemical spill?

A turn on the safety shower to flood the floor with water
B add excess calcium carbonate until no more effervescence is seen
C add concentrated sodium hydroxide and detect the end point using an indicator
D add excess silver nitrate to precipitate all the chloride ions from the hydrochloric acid

14 Two acids **P** and **Q** of the same concentration were reacted with aqueous sodium hydroxide.

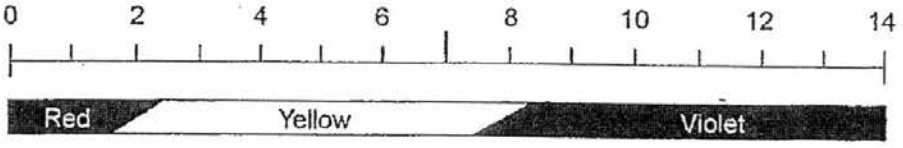
Which one of the following statements explains why a larger volume of **P** would be required to achieve the end-point as compared to **Q**?

A **P** is a strong acid but **Q** is a weak acid.
B **P** is a weak acid but **Q** is a strong acid.
C **P** is a monobasic acid but **Q** is a dibasic acid.
D **P** is a dibasic acid but **Q** is a monobasic acid.

15 A piece of magnesium ribbon does not react when placed in a solution of hydrogen chloride in methylbenzene. Which of the following actions would cause a reaction to occur?

A adding water and stirring well
B warm the mixture gently over a flame
C using magnesium powder instead of magnesium ribbon
D saturating the solution by bubbling in more hydrogen chloride gas

16 The scale below shows the colour of *m*-cresol purple indicator in solutions of different pH.



In which reaction would the resulting mixture turn the *m*-cresol purple indicator violet?

A adding barium oxide to water
B adding aluminium oxide to water
C adding ammonium nitrate to water
D adding phosphorus(V) oxide to water

17 Which of the following solutions can be used to distinguish between sodium hydroxide solution and aqueous ammonia?

A zinc sulfate solution
B iron(II) chloride solution
C iron(III) chloride solution
D aluminium sulfate solution

18 When excess nitric acid was added to a mixture of two solids, a colourless gas was evolved and some, but not all of the mixture dissolves.

What could the mixture contain?

A barium chloride and calcium sulfate
B magnesium sulfate and calcium oxide
C lead(II) chloride and calcium carbonate
D calcium carbonate and calcium hydroxide

19 In an attempt to prepare magnesium sulfate, a student added excess sulfuric acid to magnesium.

What is the implication of performing this step?

A A colourless, odourless gas is evolved.
B All sulfuric acid would be completely reacted.
C The mixture has to be filtered to remove unwanted magnesium.
D Sulfuric acid would not be completely removed in the separation process.

20 The relative atomic mass of magnesium is 24. This means that

A all atoms of magnesium are 2 times heavier than $\frac{1}{12}$ of a carbon-12 atom.

B all atoms of magnesium are 24 times heavier than $\frac{1}{12}$ of a carbon-12 atom.

C the average mass of a magnesium atom is 2 times heavier than than $\frac{1}{12}$ of a carbon-12 atom.

D the average mass of a magnesium atom is 24 times heavier than $\frac{1}{12}$ of a carbon-12 atom.

21 One of the minerals that makes up the jade gemstone is jadeite, which can be represented by the formula $NaAlSi_2O_x$. The percentage by mass of oxygen in jadeite is 47.5%.

What is the value of x?

A 3
B 4
C 5
D 6

22 What mass of water would have the same number of hydrogen atoms as 8.5 g of ammonia gas?

A 9.0 g
B 13.5 g
C 18.0 g
D 27.0 g

23 Elemental bromine is a red-brown liquid at room temperature, corrosive and toxic. The density of liquid bromine at 20°C is 3.1 g/cm^3.

How many moles are present in 0.024 dm^3 of liquid bromine?

A 0.001 mol
B 0.019 mol
C 0.465 mol
D 0.930 mol

24 Ammonia gas can be prepared in the laboratory by reaction of an alkali with a particular salt. Which one of the following statements about this method is **incorrect**?

A Water is a product of the reaction and should be removed with calcium oxide.
B Unlike the Haber process, this reaction is carried out under atmospheric pressure.
C A suitable pair of reactants for this reaction is sodium chloride and ammonium hydroxide.
D If any of the reactants are aqueous solutions, the volume of ammonia gas collected is lower due to its high solubility in water.

25 Which one of the following exhaust gases cannot be removed by installing a catalytic converter in a vehicle?

A carbon dioxide
B unburnt hydrocarbons
C carbon monoxide
D nitrogen dioxide

26 In a factory producing liquefied air, one of the pipes carrying dry air at –80°C became blocked with a white solid. The white solid is found to be one of the substances in the table below.

substance	melting point/ °C
ice	0
carbon dioxide	–57
argon	–189
nitrogen	–210

What is this white solid?

A argon
B ice
C carbon dioxide
D nitrogen

27 Nitrogen and oxygen react according to the following equation:

$$N_2(g) + 2\,O_2(g) \rightarrow 2\,NO_2(g) \qquad \Delta H = -66\ kJ/mol$$

Why is the enthalpy change negative for this reaction?

A More bonds formed than broken.
B More bonds are broken than formed.
C The total energy absorbed in bond breaking is more than the total energy released in bond making.
D The total energy absorbed in bond breaking is less than the total energy released in bond making.

28 In which of the following reactions is the underlined substance acting as an oxidising agent?

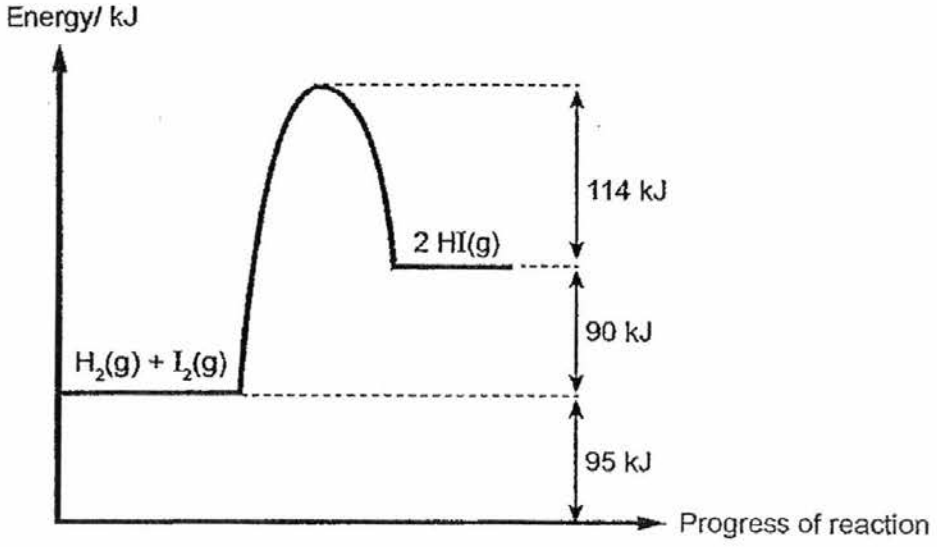
A $Cl_2 + \underline{2\,I^-} \rightarrow 2\,Cl^- + I_2$
B $\underline{Zn} + H_2SO_4 \rightarrow ZnSO_4 + H_2$
C $\underline{Fe^{2+}} + 2\,H^+ + H_2O_2 \rightarrow Fe^{3+} + H_2O$
D $\underline{CuO} + H_2 \rightarrow Cu + H_2O$

29 What colour changes occur when excess sulfur dioxide is passed through aqueous potassium iodide and acidified potassium manganate(VII) separately?

	aqueous potassium iodide	acidified potassium manganate(VII)
A	colourless to brown	no change
B	colourless to brown	purple to colourless
C	no change	no change
D	no change	purple to colourless

30 The energy profile diagram for the forward reaction between hydrogen and iodine is as shown below.

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$$



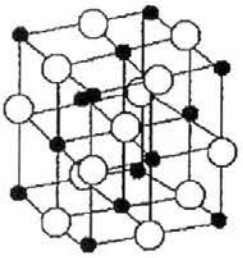
What is the activation energy of the backward reaction?

A 90 kJ
B 95 kJ
C 114 kJ
D 204 kJ

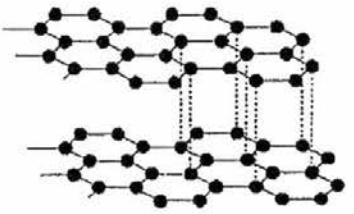
Section B (50 marks)
Answer **all** questions.

For Examiner's Use

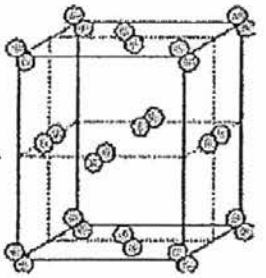
B1 **(a)** The three diagrams below represent part of the structure of potassium bromide, graphite and iodine at room temperature.



potassium bromide



graphite



iodine

(i) Complete the following table.

substances	particles involved	attractive force between particles
potassium bromide	*potassium ions and bromide ions*	
graphite		*covalent bond*
iodine		

[2]

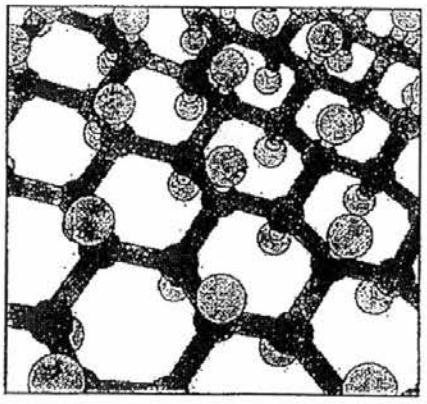
(ii) Describe the movement and arrangement of iodine at room temperature and pressure.

.....

..... [1]

(b) In 2009 a new material graphene was discovered and made from graphite. The diagram shows part of a model of the structure of graphene. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.

For Examiner's Use



(i) Unlike graphite, graphene does not conduct electricity. Explain why graphene is unable to conduct electricity.

.....

..... [1]

(ii) Explain why graphite is an element but graphene is a compound.

.....

..... [1]

(iii) State and explain whether graphite is oxidised or reduced to form graphene.

.....

..... [1]

[Total: 6]

B2 The table shows the gases in the atmospheres of five planets. The crew of a spacecraft intends to land on these planets.

For Examiner's Use

planet	atmosphere
Jupiter	ammonia, helium, hydrogen and methane
Mars	carbon dioxide
Mercury	no atmosphere
Pluto	methane
Venus	carbon dioxide and sulfur dioxide

(a) Name a common gas that will be needed by the crew on these planets.

..... [1]

(b) Venus surface temperature is much higher than that of the Earth. Explain why.

.....

..... [2]

(c) The spacecraft's body is made of durable alloys of titanium, aluminium and magnesium.

Which planet's atmosphere will most quickly corrode the spacecraft? Explain your answer.

.....

..... [2]

(d) Suggest why it is unlikely to find water on Jupiter.

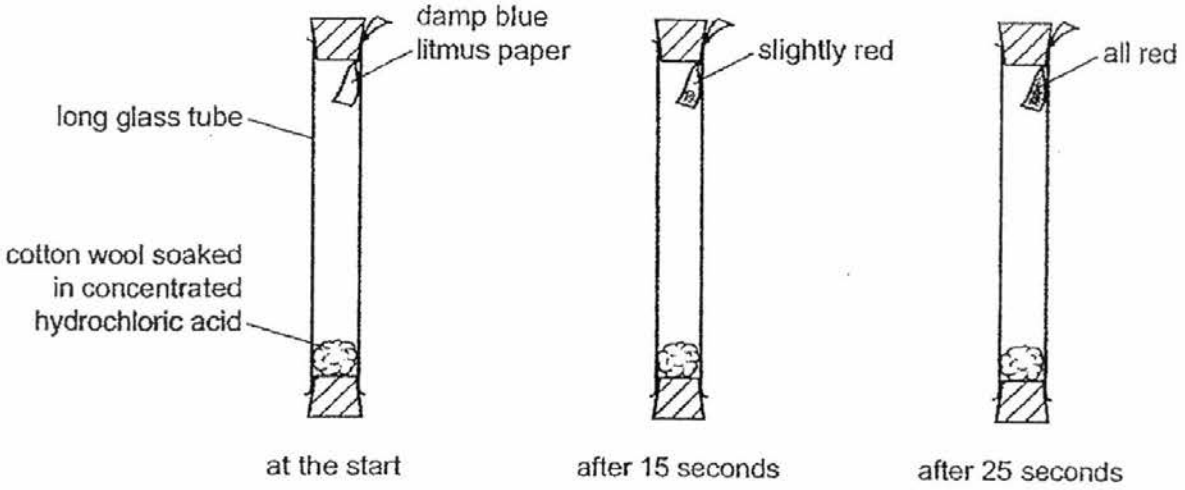
.....

..... [1]

[Total: 6]

B3 **(a)** A student set up the apparatus shown below.
The concentrated hydrochloric acid gives off hydrogen chloride gas.
After 15 seconds, the damp blue litmus paper begins to turn red.
After 25 seconds, the litmus paper has turned completely red.

For Examiner's Use



(i) Use ideas about moving particles to explain these observations.

.....

.....

.....

..... [3]

(ii) State and explain how the results of the experiment would differ if the cotton wool was soaked in concentrated nitric acid, HNO_3 instead, which also gives off an acidic vapour.

.....

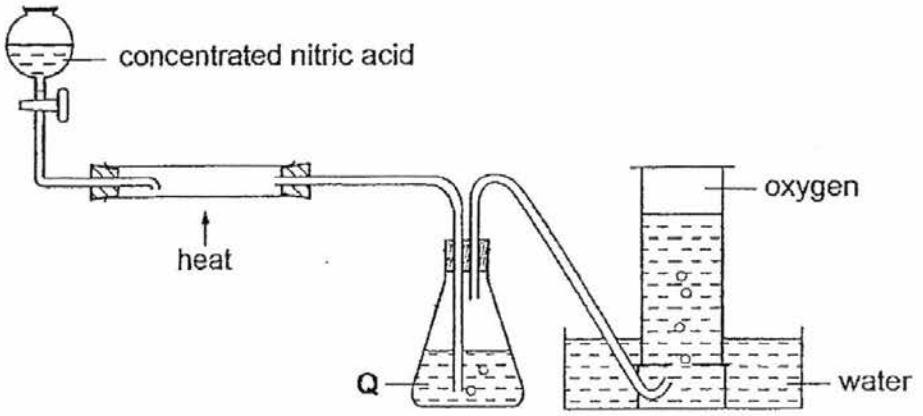
..... [2]

For Examiner's Use

(b) Concentrated nitric acid is not very stable and undergoes a decomposition reaction on strong heating to nitrogen dioxide, water and oxygen.

$$4\,HNO_3 \rightarrow 2\,H_2O + 4\,NO_2 + O_2$$

The figure below shows the set-up of an experiment used to demonstrate that one of the products of the decomposition reaction is oxygen gas.



The combustion tube is heated strongly and concentrated nitric acid is allowed to flow into it. Due to the heat, it decomposes, liberating the corresponding gases.

(i) Suggest the role of liquid **Q**.

..... [1]

(ii) Hence, give a suitable identity for liquid **Q**.

..... [1]

(iii) Explain why the sample of oxygen gas collected using the water displacement method may not be pure.

.....

..... [1]

(iv) State the industrial method used to obtain oxygen from air.

..... [1]

[Total: 9]

B4 Sodium hydrogencarbonate is a chemical compound with the formula $NaHCO_3$. It is a crystalline white solid and is found dissolved in many mineral springs. A wide variety of applications in clinical use and cooking follows from its amphoteric properties.

For Examiner's Use

(a) Explain the meaning of the term *amphoteric*.

.....

..... [1]

(b) 1.600 g of an impure sample of solid sodium hydrogen carbonate was dissolved in 100.0 cm^3 of water. 25.0 cm^3 of this solution required 23.50 cm^3 of 0.200 mol/dm^3 hydrochloric acid to achieve the end-point of titration.

$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$$

(i) Describe how the end-point of the titration could be determined.

.....

..... [2]

(ii) Calculate the mass of sodium hydrogen carbonate in 25.0 cm^3 of the solution.

[2]

(iii) Hence, calculate the percentage purity of the sodium hydrogen carbonate sample.

[1]

(iv) Write an ionic equation for the reaction.

.....

[2]

For Examiner's Use

(v) Comment on how the results would be affected if the burette was only rinsed with water prior to filling with dilute hydrochloric acid.

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[2]

[Total: 10]

B5 Ammonium iron(II) sulfate, or Mohr's Salt (named after a German scientist Karl Friedrich Mohr), is a green crystalline compound with the chemical formula $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$. Since it contains two different cations, Fe^{2+} and NH_4^+, it is classified as a double salt.

For Examiner's Use

When a double salt such as Mohr's salt is made, the two individual salts are mixed together in a 1:1 molar ratio, dissolved in water and the solution crystallised.

(a) **(i)** Describe tests to confirm the identity of the two cations in Mohr's salt and state the expected observations.

.....

.....

.....

..... [3]

(ii) Describe a simple test to show the presence of water of crystallisation in Mohr's salt and state the expected observations.

.....

.....

.....

..... [2]

(b) Based on the chemical formula of Mohr's Salt, suggest the names of two salts that are combined to form Mohr's Salt.

..... [1]

(c) Given an aqueous solution of Mohr's salt, outline how crystallisation can be carried out.

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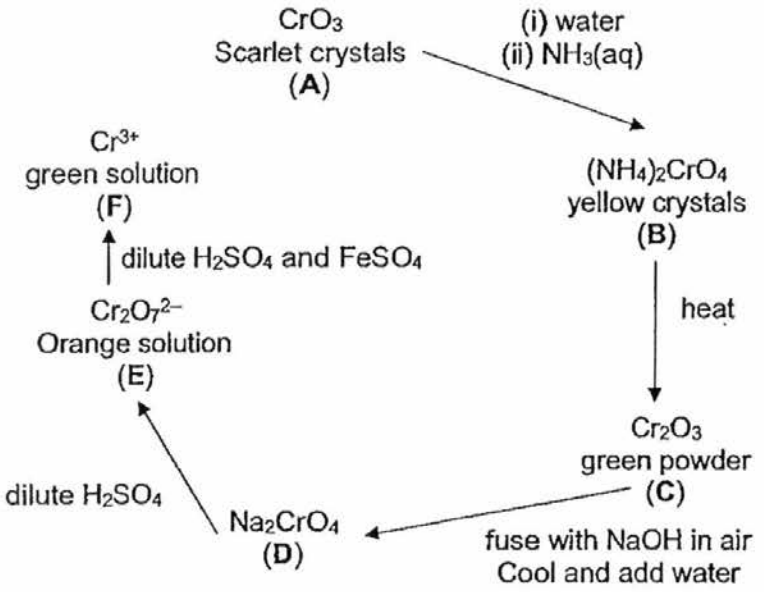
..... [2]

[Total: 8]

For Examiner's Use

B6 The diagram below shows the reaction scheme involving compounds of chromium.



(a) The complete equation for heating **B** is

$$2\,(NH_4)_2CrO_4 \rightarrow Cr_2O_3 + N_2 + 2\,NH_3 + 5\,H_2O$$

Explain, in terms of oxidation state, why this is a redox reaction.

.....

.....

.....

.....

.....

..... [3]

(b) Which steps, other than **B** to **C**, involve redox?

..... [2]

[Total: 5]

B7 'Water gas' is a mixture containing the same number of moles of hydrogen and carbon monoxide. It is produced when steam is blown through white hot coke, C, in the following reaction.

For Examiner's Use

$$H_2O(g) + C(s) \rightarrow H_2(g) + CO(g)$$

'Water gas' was used as an industrial gaseous fuel before it was widely replaced by natural gas, which consists mainly of methane.

The table below shows the enthalpy change of combustion per mole of various substances.

substance	enthalpy change of combustion ΔH / kJ/mol
CH_4	–890
H_2	–242
CO	–283

(a) (i) Calculate the volume (measured at room temperature and pressure) of methane required to produce 1000 kJ of heat energy when burned.

..... dm^3 [1]

(ii) Calculate the volume of 'water gas' (measured at room temperature and pressure) required to produce 1000 kJ of heat energy when burned.

..... dm^3 [2]

(b) Suggest **two** reasons why 'water gas' has been widely replaced by natural gas.

.....

.....

..... [2]

(c) Is the reaction between steam and coke to form 'water gas' is an endothermic or exothermic? Explain your answer.

For Examiner's Use

.....

..... [1]

[Total: 6]

Section C (20 marks)
Answer **all** questions.

For Examiner's Use

C1 Properties of hydrocarbons.

Table 1 shows the boiling points and densities of a group of hydrocarbons called alkanes.

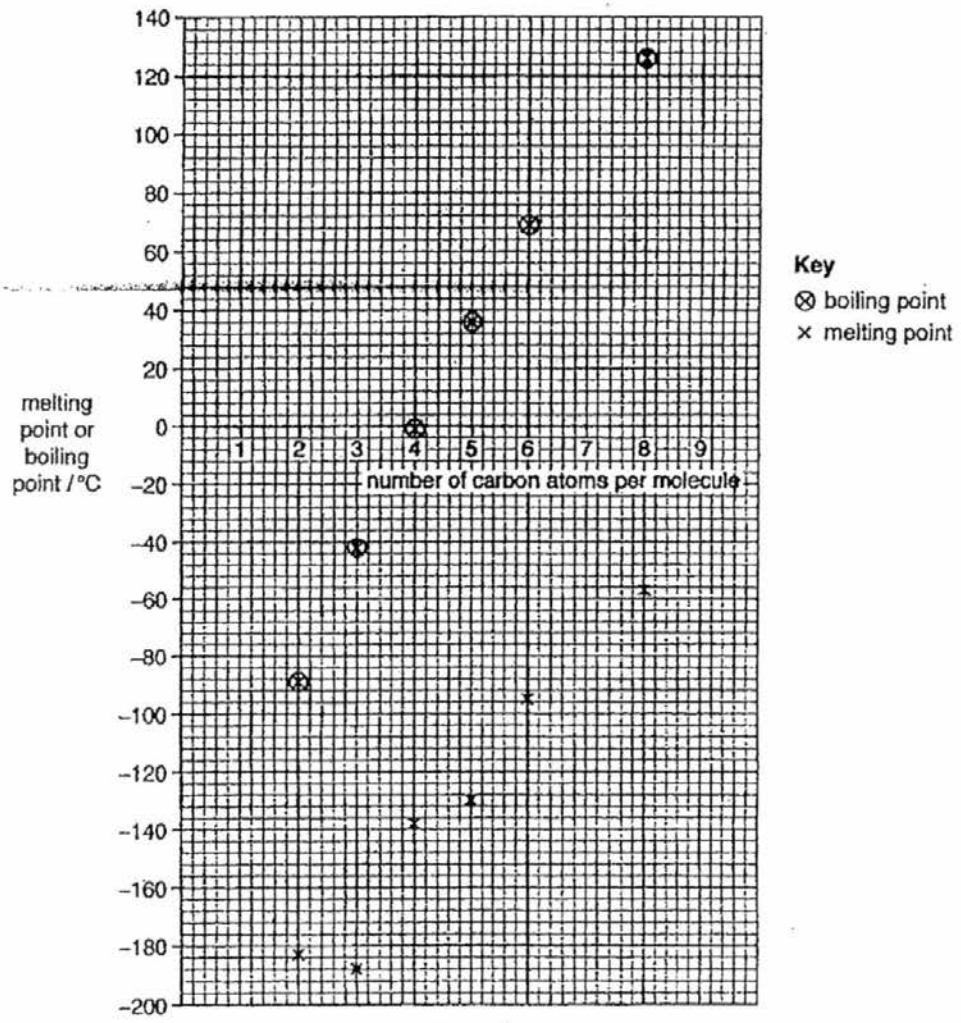
Table 1

name of alkane	formula	number of carbon atoms	boiling point/ °C	density/ g/L
methane	CH_4	1	–162	0.668
ethane	C_2H_6	2	–88	1.265
propane	C_3H_8	3	–42	1.867
butane	C_4H_{10}	4	–1	2.493
pentane	C_5H_{12}	5	36	626

Graph 1 shows the melting points and boiling points of some alkanes plotted against the number of carbon atoms in each alkane molecule.

For Examiner's Use

Graph 1



(a) Draw the 'dot-and-cross' diagram to represent the bonding in methane.

For Examiner's Use

[2]

(b) Describe one physical property, other than boiling point and density, these alkanes have in common.

.....

.....

..... [1]

(c) Using the information from **Table 1** and **Graph 1**, describe the relationship between number of carbon atoms and boiling point. Suggest an explanation for this relationship.

.....

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..... [3]

(d) Explain, with reference to the arrangement of particles, why the density of pentane is significantly higher than the other alkanes.

For Examiner's Use

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..... [2]

(e) Heptane is an alkane with 7 carbon atoms.

Using the information provided, predict the chemical formula, melting point and boiling point of heptane.

chemical formula: .....

melting point: ..... °C boiling point: .....°C [2]

[Total: 10]

C2 Ammonia is manufactured on a large scale by the Haber process. It involves reacting nitrogen and hydrogen over a catalyst.

For Examiner's Use

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Table 2 gives information about the percentage yield of ammonia obtained in the Haber process under different conditions (1 atm = 1 atmosphere).

Table 2

pressure/atm	temperature/°C			
	150	**300**	**450**	**600**
10	50.7%	14.7%	3.9%	1.2%
100	81.7%	52.5%	25.2%	10.6%
200	89.1%	66.7%	?	18.3%
300	89.9%	71.1%	47.1%	24.4%
400	94.6%	79.7%	55.4%	31.9%
600	95.4%	84.2%	65.2%	42.3%

(a) Explain why the Haber process is unable to give a 100% yield of ammonia.

.....

.....

..... [2]

(b) What trends are shown by the data in **Table 2**?

.....

.....

..... [2]

(c) The actual conditions used in the Haber process is 450 °C and 200 atm. Predict the percentage yield under these conditions.

For Examiner's Use

..... [1]

(d) (i) Using information from **Table 2**, calculate the maximum mass of ammonia formed at equilibrium if 378 g of N_2 and 81 g of H_2 are allowed to react in a sealed vessel at 150 °C and 600 atm.

[3]

(ii) Explain why the conditions of 150 °C and 600 atm cannot be used even if it produces that highest yield of ammonia.

.....

.....

.....

..... [2]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VIII	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	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 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
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

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

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

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

CHIJ St. Joseph's

Secondary 3 Express Chemistry(SPA) 5073
2016 SA2 Mark Scheme

SECTION A

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

SECTION B

B1 (a) (i) — 2 marks

substances	particles involved	attractive force between particles
potassium bromide	*potassium ions and bromide ions*	Ionic bond / electrostatic forces of attraction
graphite	Carbon atoms	*covalent bond*
iodine	Iodine **molecules**	Intermolecular forces of attraction / Van der Waal's forces

1 m for 2 boxes (max 2 m)

(ii) Iodine molecules vibrate about fixed positions in a closely packed, regular/orderly arrangement — 1

(b) (i) Unlike graphite, graphene, all the electrons are involved in bonding, so there are no delocalised electrons available to carry charge through the substance. — 1

WRONG: FREE ELECTRONS
CORRECT: FREE MOVING ELECTRONS

(ii) Graphite – only carbon atoms but
Graphene – carbon and hydrogen atoms chemically combined — 1

(iii) Graphite is reduced. Graphite gains hydrogen to form graphene. — 1

B2	(a)	Oxygen gas	1
	(b)	Sulfur dioxide and carbon dioxide are both **greenhouse gases.** Hence it would **trapping heat energy,** increasing the surface temperature of venus. OR There is a **higher concentration/ percentage** of carbon dioxide in Venus' atmosphere, hence **trapping more heat,** increasing the temperature of Venus. Reject: global warming	1 1
	(c)	Venus. **Sulfur dioxide** and carbon dioxide are both **acidic gases** that can react with/ corrode the **metals** used to make the spacecraft's body.	1 1
	(d)	There is **no oxygen** in Jupiter's atmosphere. To form water, the **hydrogen** needs to react with oxygen.	1

B3	(a)	(i)	random movement of particles/move freely diffusion/diffuse across/to fill up available space Reject: higher to lower concentration HC*l* molecules collide with litmus paper/come into contact/OWTTE	1 1 1
		(ii)	Longer time taken for blue litmus paper to turn red. HNO_3 has a higher relative molecular mass of 68 (vs. 36.5), thus slower rate of diffusion.	1 1
	(b)	(i)	To remove water vapour and nitrogen dioxide.	1
		(ii)	Any alkali Reject: water (not very effective)	1
		(iii)	Set-up has spaces containing air which is a mixture of gases/contains other gases, mainly nitrogen, which will be collected together with oxygen. Accept: water vapour present as over-water method is used	1
		(iv)	Fractional distillation of liquid air	1

B4	(a)	Able to react with either an acid or an alkali/base to produce salt and water only.		1
	(b)	(i)	**Method 1** Methyl orange indicator [1] Observe colour change from yellow to orange [1] **Method 2** Use a pH probe [1] Observe pH 7/sharp change in pH signals end point [1]	2
		(ii)	$n HCl$ in 23.50 $cm^3 = \frac{23.50}{1000} \times 0.200 = 0.00470$ mol No ecf if this step is wrong. No marks if working is not shown. Mole ratio of $HCl : NaHCO_3 = 1 : 1$ Mass of $NaHCO_3$ in 25.0 cm^3 = 0.00470 mol × 84 = 0.3948 g Allow if mole ratio not stated. No marks if working not shown	1 1
		(iii)	Mass of $NaHCO_3$ in 1.600 g of an impure sample = 0.3948 × 4 = 1.5792 g % Purity = $\frac{1.5972}{1.600} \times 100\% = 98.7\%$ No marks if students put 0.3948 g into the % purity equation.	1
		(iv)	$HCO_3^-(aq) + H^+(aq) \rightarrow CO_2(g) + H_2O(l)$	1
		(v)	Water in burette will dilute the hydrochloric acid **Any one from** • Larger volume of acid is required to reach end point • Percentage purity is higher than expected	1 1

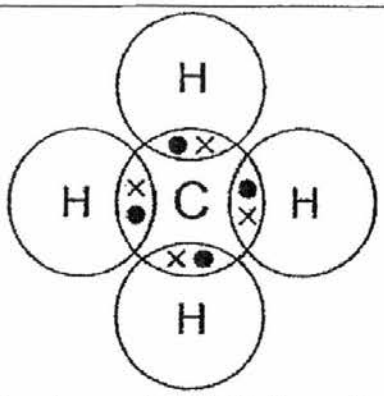
B5	(a)	(i)	1) To 2 cm^3 of the mixture in a test tube, add aqueous sodium hydroxide dropwise until in excess. 2) Green precipitate formed that is insoluble in excess sodium hydroxide. 3) When the mixture is warmed, the gas evolved turns moist red litmus paper blue.	1 1 1
		(ii)	Heat a spatula of Mohr's salt crystals in a boiling tube. Droplets of liquid will form on the walls of the boiling tube. **Any 1 from** • Collect and measure the boiling point of this colourless liquid, it should be 100°C. • Test the liquid with cobalt(II) chloride paper, which turns blue to pink.	1 1

	(b)	iron(II) sulfate and ammonium sulfate	1
	(c)	**Two points = 1 mark** • Heat the solution till saturation (cool the solution to allow crystals to form) • Filter to obtain residue, • wash salt crystals with a little cold distilled water and • dry crystals between sheets of filter paper	2

B6	(a)	The N **in $(NH_4)_2CrO_4$** has increased in oxidation state from -3 to 0 in nitrogen. Hence **$(NH_4)_2CrO_4$** has been oxidised. The Cr in $(NH_4)_2CrO_4$ has decreased in oxidation state from +6 to +3 in Cr_2O_3. Hence $(NH_4)_2CrO_4$ has been reduced. Since oxidation and reduction take place simultaneously, this reaction is a redox reaction.	1 1 1
	(b)	C to D and E to F	2

B7	(a)	(i)	Volume = 1000 x 24/890 = 27.0 dm^3	1
		(ii)	1000/ (242 + 283) = 1.9047 mol of water gas Volume of water gas = 1.9047 x 2 x 24 =91.4 dm^3	1 1
	(b)	A **lower volume of methane** is needed to produce the same amount /1000 kJ of heat. CO a **poisonous gas** or it can **cause death** when breathed in.		1 1
	(c)	It is an endothermic reaction. Both the H_2O and C is **heated before** the reaction.		1

SECTION C

C1	(a)	 1 m for number of H atoms; 1 m for shared electrons	2
	(b)	Insolublity in water / non-conductor of electricity in all states.	1
	(c)	The more the number of carbon atoms the higher the boiling point. More carbon atoms / larger molecular size, the stronger the intermolecular forces of attraction. Hence **more energy is required to overcome these forces**, resulting in a higher boiling point.	1 1 1
	(d)	Pentane is a **liquid at room temperature** while the **other alkanes are gases.** Hence the **particles** of pentane are **much more closely packed**, which means there are **more particles per unit volume / more particles in the same volume** of pentane, which results in a **larger density.**	1 1
	(e)	C_7H_{16} Accept range between • m.p.: –64 °C to –72 °C • b.p.: 92 °C to 108 °C	1 1

C2	(a)		The reaction between nitrogen and hydrogen is a <u>reversible</u> process. Reject: can be reversed Thus, some of the ammonia produced will be converted/decomposed back into nitrogen and hydrogen.	1 1
	(b)		Increasing temperature decreases the percentage yield of ammonia Increasing pressure increases the percentage yield of ammonia	1 1
	(c)		Accept value range between 30% to 40%. Units must be stated.	1
	(d)	(i)	nN_2 = 13.5 mol and nH_2 = 40.5 mol (nN_2 : nNH_3 = 1:2) therefore nNH_3 = 27 mol mass of NH_3 (theoretical) = 459 g % yield at 200 atm and 450 °C = 95.4% Equilibrium mass of NH_3 = 437.9 g	1 1 1
		(ii)	Pressure of 600 atm very high pressure → dangerous/safety risks/expensive Temperature of 150°C is not practical as the reaction rate will be very slow. Thus the optimum pressure and temperature for Haber process are 200 atm and 450°C	1 1