NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CHEMISTRY 8872/01

Paper 1 Multiple Choice **25 Sep 2017**

50 minutes

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, CT and NRIC / FIN on the Answer Sheet in the spaces provided.

There are **thirty** questions in this paper. 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 *Use of the Data Booklet is relevant to this question*.

The compound S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen.

What volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S_2O_7 is hydrolysed?

A 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

2 Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula of $Ca_2Al_aSi_bO_{12}(OH).6½H_2O$. Tanzanite has M_r of 571.5.

Its chemical composition is 14.04% calcium, 14.17% aluminium, 14.75 % silicon, 54.59% oxygen and 2.45% hydrogen.

What are the values of a and b?

	a	b
A	1	1
B	2	3
C	3	3
D	6	1

3 Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3?

A −2, −4 **B** +2, +6 **C** +4, −6 **D** +4, −4

4 Tritium is the isotope of hydrogen ^{3}H.

Which of the following is the same for a ^{4}He atom and a ^{3}H atom?

A the relative atomic mass

B the number of electrons

C the number of protons

D the number of neutrons

5 *Use of the Data Booklet is relevant to this question.*

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

A 5 **B** 13 **C** 15 **D** 21

6 Why does aluminium chloride, Al_2Cl_6, sublime at a relatively low temperature of 180 ^{o}C?

A The intermolecular forces between the Al_2Cl_6 molecules are weak.

B The co-ordinate bonds between aluminium and chlorine are weak.

C The covalent bonds between aluminium and chlorine are weak.

D The ionic bonds between aluminium and chlorine are weak.

7 Which of these statements cannot be explained by hydrogen bonding?

A At 0 ^{o}C, ice floats on water.

B At 20 ^{o}C, propanone and propanal are miscible.

C The relative molecular mass of ethanoic acid in benzene is 120.

D The boiling point of propan-2-ol and propanone are 82 ^{o}C and 56 ^{o}C respectively.

8 Silica, SiO_2 has many industrial uses, including the manufacture of glass, ceramic and cement.

In the structure of solid SiO_2

- each silicon atom is bonded to x oxygen atoms,
- each oxygen atom is bonded to y silicon atoms,
- each bond is a z bond.

What is the correct combination of x, y and z in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

9 Ethanol, commonly made from biomass such as sugarcane is increasingly being used as a green fuel due to its lower greenhouse gas emissions as compared to burning fossil fuels.

The appropriate enthalpy changes of formation are given in the table.

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
Carbon dioxide	−393
Water	−286
Ethanol	−277

What is the enthalpy change of combustion of ethanol?

A $\Delta H_c^{\ominus} = -1921$ kJ mol^{-1}

B $\Delta H_c^{\ominus} = -1367$ kJ mol^{-1}

C $\Delta H_c^{\ominus} = -956$ kJ mol^{-1}

D $\Delta H_c^{\ominus} = -402$ kJ mol^{-1}

10 A student mixed 30.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature rose by 2.5 ^oC. Assume that 4.20 J is required to raise the temperature of 1 cm^3 of the solution by 1 K.

Which is the enthalpy change of neutralisation?

A $\Delta H_n^{\ominus} = -330$ kJ mol^{-1}

B $\Delta H_n^{\ominus} = -66$ kJ mol^{-1}

C $\Delta H_n^{\ominus} = -55$ kJ mol^{-1}

D $\Delta H_n^{\ominus} = -30$ kJ mol^{-1}

11 $Na_2S_2O_3$ reacts with dilute HC*l* to give a pale yellow precipitate. If 1 cm^3 of 0.1 mol dm^{-3} HC*l* is added to 10 cm^3 of 0.02 mol dm^{-3} $Na_2S_2O_3$, the precipitate forms slowly.

If the experiment is repeated with 1 cm^3 of 0.1 mol dm^{-3} HC*l* and 10 cm^3 of 0.05 mol dm^{-3} $Na_2S_2O_3$, the precipitate forms more quickly.

Why is there a difference in observation when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used?

A The reactant particles collide more frequently.

B The reaction proceeds by a different pathway.

C The activation energy of the reaction is lower.

D The collisions between reactant particles are more violent.

12 Which statement about dynamic equilibrium is always correct?

A Equal amounts of reactants and products are present.

B Concentrations of reactants and products remain constant.

C The rates of the forward and reverse reactions are equal to zero.

D The rate constant for the forward reaction equals the rate constant for the reverse reaction.

13 The following equilibrium is set up in a mixture of concentrated nitric acid and sulfuric acid.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the reaction mixture?

	HNO_3	H_2SO_4	$H_2NO_3^+$	HSO_4^-
A	acid	acid	base	base
B	acid	base	acid	base
C	base	acid	acid	base
D	acid	base	base	acid

14 The table gives the concentrations and pH values of the aqueous solutions of two compounds, F and G. Either compound could be an acid or a base.

	F	G
concentration	2 mol dm^{-3}	2 mol dm^{-3}
pH	6	9

Student P concluded that G is a weak base.

Student Q concluded that the extent of dissociation is lower in F(aq) than in G(aq).

Which of the students are correct?

A both P and Q

B neither P nor Q

C P only

D Q only

15 The value of the ionic product, K_w, varies with temperature.

temperature / ^oC	K_w / $mol^2\ dm^{-6}$
25	1.0×10^{-14}
62	1.0×10^{-13}

What can be deduced from this information?

A Water is not a neutral liquid at 62 ^oC.

B The ionic dissociation of water is an endothermic process.

C Hydrogen bonding between water molecules increases as temperature rises.

D The ionic dissociation of water increases by a factor of 5 between 25 ^oC and 62 ^oC.

16 Elements X and Y are both in Period 3. Element X has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element Y. Elements X and Y react together to form compound Z.

Which compound could be Z?

A $MgCl_2$ **B** SCl_2 **C** Na_2S **D** PCl_5

17 The electrical conductivities of two compounds, H and I, are shown in the table.

Electrical conductivity	H	I
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

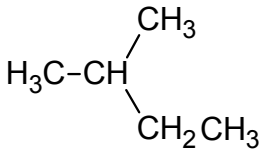
What could compounds H and I be?

	H	I
A	NaF	$SiCl_4$
B	NaF	Al_2O_3
C	Al_2O_3	$SiCl_4$
D	$SiCl_4$	Al_2O_3

18 Alcohols can be classified into primary, secondary and tertiary alcohols. How many structural isomers are there for each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

19 When 2-methylbutane reacts with limited chlorine gas in the presence of uv light, monochlorinated compounds are formed.



2-methylbutane

Which of the following statements is **not** correct?

A H_2 molecule is a by-product of the reaction.

B Four different monochlorinated isomers may be formed.

C The reaction can take place if heat is used instead of uv light.

D The colour in the reaction vessel changes from yellow-green to white.

20 S and T are isomers of $C_4H_6Br_2$.

S **T**

Which of the following are three **different** possible products formed when S and T isomers react with HBr?

A	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CHBrCHBrCH_3$
B	$(CH_3)_2CBrCHBr_2$	$CHBr_2CBr(CH_3)_2$	$CH_3CHBrCBr_2CH_3$
C	$(CH_3)_2CBrCBr_3$	$(CH_3)_2CHCBr_3$	$CH_3CBr_2CHBrCH_3$
D	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CBr_2CHBrCH_3$

21 A catalytic converter is part of the exhaust system of many modern cars. Which reactions occur in a catalytic converter?

A $2CO + 2NO \rightarrow 2CO_2 + N_2$

B $2SO_2 + 2NO \rightarrow 2SO_3 + N_2$

C $C_6H_{14} \rightarrow C_2H_4 + C_4H_{10}$

D $CO_2 + NO \rightarrow CO + NO_2$

22 Sodium hydroxide reacts with chloropropane in a series of steps to produce propanal.

$$CH_3CH_2CH_2Cl \longrightarrow \longrightarrow CH_3CH_2CHO$$

Which of the following terms describe the first step of this reaction?

A addition

B elimaintion

C oxidation

D substitution

23 Which of the following reagents can be used to differentiate the two alcohols?

$CH_3CH_2CH_2CH(OH)CH_3$ $CH_3CH_2CH(OH)CH_2CH_3$

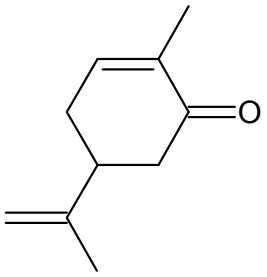
A Acidified $K_2Cr_2O_7$

B Acidified $KMnO_4$

C Tollens' reagent

D I_2 (aq), NaOH

24 Carvone is used to give the flavour of spearmint in chewing gums.



Carvone

Prolonged heating of carvone with hot concentrated acidified potassium manganate(VII) produces compound L.

What is the maximum number of molecules of 2,4-dinitrophenylhydrazine that will react with one molecule of L?

A 1 **B** 2 **C** 3 **D** 4

25 Butanedioic acid may be synthesised in two steps from 1,2-dibromoethane.

$$Br\,CH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which of the following reagents can be used for this synthesis?

	step 1	step 2
A	HCN and KCN	HC*l*
B	$HCO_2^-Na^+$	HC*l*
C	NaOH	$K_2Cr_2O_7$ and H_2SO_4
D	KCN in ethanol	H_2SO_4

Section B

For each of the questions in this section one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

26 Methanol is manufactured industrially by the catalytic reaction shown.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H < 0$$

The operating conditions are:

- 250 ^oC
- a pressure between 50 atm and 100 atm
- a copper-based catalyst

Which factor influences the choice of these conditions?

1 The catalyst increases the equilibrium yield of methanol

2 At high pressures, the rate of formation of methanol increases.

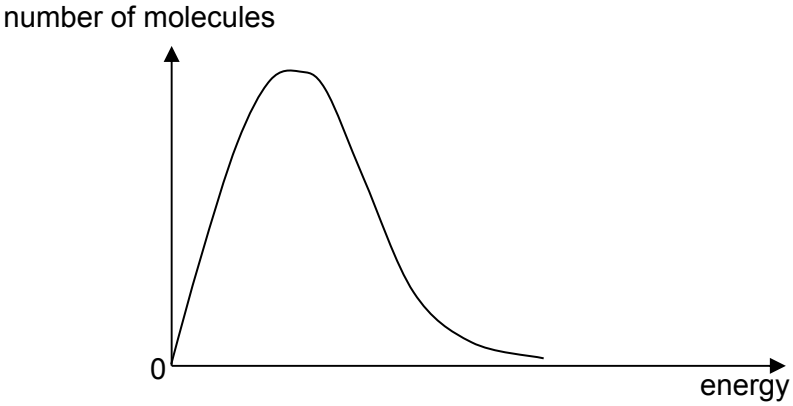
3 At lower temperatures, the equilibrium yield of methanol increases.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

27 The graph below shows the Boltzmann distribution of molecular energies.



Which of the following statements are correct?

1 Raising the temperature increases the spread of molecular energies.

2 The area under the curve is proportional to the number of molecules present.

3 Raising the temperature always increases the number of molecules with a given energy.

28 A little water is added to each of the following compounds and the mixture warmed. For which compounds will an acidic gas be evolved?

1 aluminium chloride

2 silicon chloride

3 phosphorus pentachloride

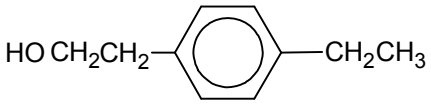
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

29 Which of the following structures will give benzene–1,4–dicarboxylic acid as the only organic product when heated with acidified $KMnO_4$ under reflux?

1



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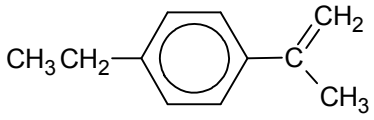

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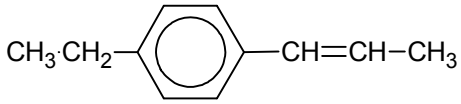


30 Bromoethane reacts with NaOH in different ways depending on the solvent used. Which of the following are correct?

	solvent	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

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

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

CLASS

TUTOR'S NAME

CHEMISTRY

8872/02

Paper 2

11 Sep 2017

2 hours

Candidates answer Section A on the Question Paper

Additional Materials: Answer Paper
Data Booklet
Graph paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section **A**
Answer **all** the questions.

Section **B**
Answer **two** questions on separate answer paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
B5	
B6	
B7	
Total	**/80**

For Examiner's Use

Section A

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

1 (a) (i) The bond energy of the carbon-carbon single bond in the ethane molecule is 350 kJ mol^{-1}. It was expected that bond energy of the carbon-carbon double bond in the ethene molecule to be twice that of the carbon-carbon single bond in the ethane. However, actual bond energy of the carbon-carbon double bond in the ethene molecule is only 610 kJ mol^{-1}. Account for the difference.

……

……

……

…….....[2]

(ii) Ethanol is miscible in water because of interactions between molecules of ethanol and water. Draw a labelled diagram to show the interaction between a molecule of ethanol and a molecule of water.

[1]

(iii) Explain why unlike ethanol, butanol is immiscible in water.

……

……

……

…….....[1]

(b) The molecule of benzene, C_6H_6, is a regular hexagon in which the π electrons are described as being delocalised.

(i) Draw a diagram to illustrate the delocalisation of π electrons in benzene.

[1]

(ii) The delocalised π electrons results in characteristic chemical properties of benzene. Explain why benzene undergo substitution rather than addition reactions.

……

……

……

…….....[1]

(iii) Compare the relative ease of oxidation of benzene and methylbenzene. State the reagents and conditions necessary for oxidation to take place.

……

……

……

…….....[2]

(c) Free chlorine atoms, initially formed in the upper atmosphere by the action of ultraviolet light on chlorofluorocarbons, CFCs, are believed to be responsible for the destruction of the ozone layer.

By reference to the Data Booklet, suggest why industrial use of CFCs such as CF_2CI_2 were replaced by flurohydrocarbons such as $C_2H_2F_4$.

……

……

……

……

[2]

[Total: 10]

2 (a) Lead(II) chromate, $PbCrO_4$, has a vivid yellow colour and is insoluble in water. It is used in paints under the name chrome yellow. However when exposed to atmosphere containing sulfur dioxide, SO_2, the yellow colour slowly changes due to formation of Cr^{3+}.

(i) Write the half equation for the reaction of CrO_4^{2-} to form Cr^{3+}.

……[1]

(ii) In an experiment, 0.0150 mol of CrO_4^{2-} reacted with 0.0225 mol of SO_2. Determine the new oxidation number of sulfur.

[2]

(iii) Hence predict identity of the sulfur product from the table of sulfur-containing compounds.

Compound	S^{2-}	HSO_3^{2-}	SO_3^{2-}	SO_4^{2-}

Identity of sulfur-containing product: …….

[1]

(b) 20.00 g of lead(II) chromate is dissolved in 100 cm^3 of acid solution and allowed to stand for a long time to reach equilibrium according to the equation below:

$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O\ (l)$

$K_c = 7.55 \times 10^{12}\ mol^{-3}\ dm^9$

(i) Write a K_c expression for the above equilibrium.

[1]

(ii) Calculate initial concentration of $CrO_4^{2-}(aq)$.

[1]

(iii) At equilibrium, only **one-fifth** of the original amount of $CrO_4^{2-}(aq)$ remain, determine the equilibrium concentration of $CrO_4^{2-}(aq)$ and $Cr_2O_7^{2-}(aq)$.

[2]

(iv) Hence calculate pH of the solution.

[1]

(v) Given that aqueous CrO_4^{2-} solution is yellow in colour while aqueous $Cr_2O_7^{2-}$ solution is orange in colour, predict and explain what will be observed when aqueous NaOH is added to the above mixture in equilibrium.

……

……

……

…….....[2]

[Total: 11]

3 An unknown compound X has the molecular formula C_3H_8O and is a liquid at room temperature.

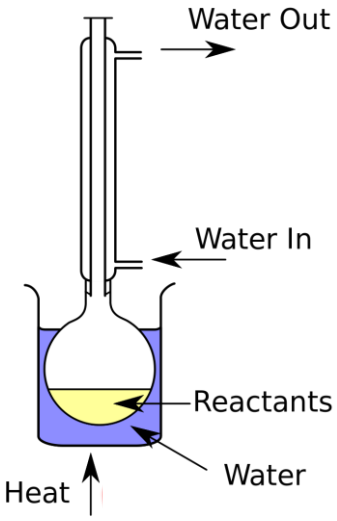
A student placed 5 cm^3 of X in a test tube and added a strip of sodium into the test tube. He observes bubbles forming vigorously at the surface of the sodium strip and floats to the surface. He suggest collecting the gas and devise a method to test it.

(a) Describe how the gas can be tested to confirm its identity, and what would be observed to confirm the identity of the gas.

……..

……..[2]

The following apparatus was assembled to carry out further experiment on X.



He first put 5 cm^3 of dilute sulfuric acid in the round bottom flask. He then added 5 drops of potassium dichromate(VI) solution followed by 2 cm^3 of X. The mixture was heated till it started boiling and a colour change was observed.

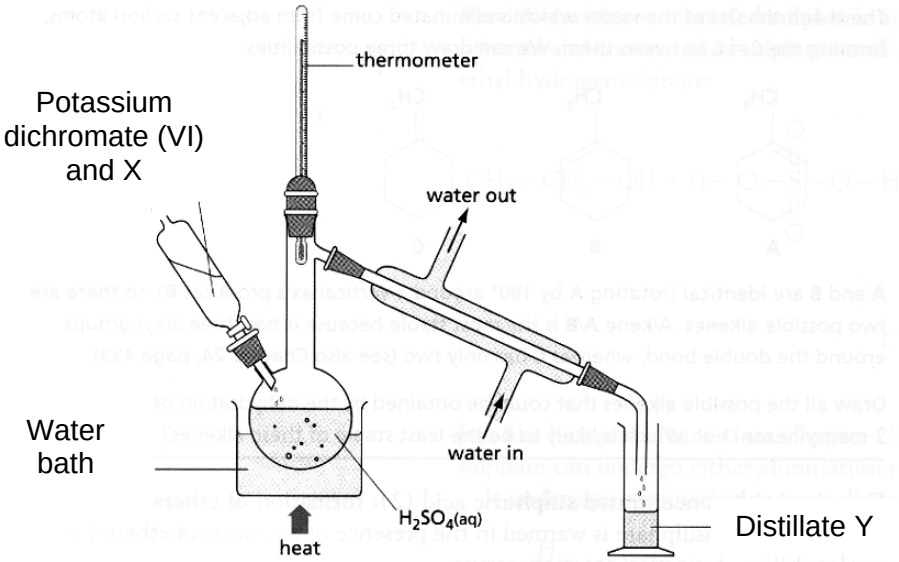
(b) **(i)** What colour change would the student see as the reaction is carried out?

…… [1]

(ii) Name the type of reaction that has occurred.

Type of reaction: …… [1]

The set-up was rearranged as shown.



He repeated the process of adding 5 cm^3 of dilute sulfuric acid into the round bottom flask, followed by 5 drops of potassium dichromate(VI) solution and 2 cm^3 of X. The distillate collected was labelled as Y.

The student observed reddish brown precipitate when he gently warmed a small sample of Y with Fehling's solution in a test tube.

(c) **(i)** Draw the structures of X and Y.

[1]

(ii) Write equation for reaction between Y and Fehling's solution.

……[1]

(iii) Suggest a simple chemical test to distinguish between X and Y. Describe clearly what will be observed. Do not repeat reagents that had been mentioned in this question.

……..

……..

……..[2]

[Total: 8]

4 The Paris Agreement, signed in 2015 by 195 countries, was aimed to slow down global warming by reducing human activities that generate emission of gases that cause harm to the environment.

Over the past decade, Singapore has adopted cleaner energy sources to fuel electricity demand, moving away from petroleum products such as diesel and fuel oil to the more environmentally-friendly fossil fuel alternative: natural gas (Methane, CH_4). It has been found that combustion of methane releases 890 kJ of heat and emits about 35 per cent less carbon dioxide than the petroleum-based oil that Singapore was using.

In many developing countries however, there is still heavy reliance on the use of coal to generate electricity. Combustion of carbon generates only 394 kJ of heat and is known to be much more polluting. The following table compares these two types of power generation.

Type of power station	Overall efficiency of power station	Amount of by-product produced per MJ of electrical energy (1MJ = 10^6J)	
		SO_2	NO_2
Coal	40%	0.31 g	0.64 g
Natural gas	51%	0.0015 g	0.11 g

For your calculations, assume that coal consists of 95% of carbon and 5% of non-combustible ash.

'Water-gas' is an equimolar mixture of hydrogen and carbon monoxide and in some cases is used in place of methane as an industrial gaseous fuel. It is produced when steam is blowing through white-hot coke in the following reaction.

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

Complete combustion of hydrogen and carbon monoxide releases 242 kJ and 283 kJ of heat respectively.

(a) Define the term *enthalpy change of combustion*.

……

……..[1]

(b) Write balanced equation with state symbols for the complete combustion of

(i) Carbon: ……..

Methane: ……..
[1]

(ii) Calculate how many moles of carbon and methane need to be burned in order to produce 1 MJ of **heat** energy.

[1]

(iii) Calculate how many moles of methane and carbon need to be burned in order to produce 1 MJ of **electrical** energy.

[1]

(c) Calculate the mass of ash that would be produced per MJ of electrical energy in a coal-fired power station.

[1]

(d) **(i)** Explain why it is important to cut down CO_2 emissions?

……

……

……[1]

(ii) Despite the obvious environmental impact of generating electricity using coal, many countries continue using coal burning power station because it is cheaper and easier to operate. Suggest why this is so.

……

……

……[1]

(e) **(i)** Use answer from **(b)(ii)** to calculate the volume of methane required to produce 1 MJ of heat energy.

[1]

(ii) Calculate the volume of water gas required to produce 1 MJ of heat energy.

[2]

(iii) Based on your calculations, or on other considerations, suggest an advantage of using natural gas rather than water gas. Give reasons for your answers.

……

……

……[1]

[Total: 11]

Section B

Answer **two** questions from this section on separate answer paper.

5 **(a)** Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidifed potassium manganate(VII) solution using a suitable indicator.

The ionic equation is shown below.

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

A 5.00 g sample of spathose was reacted with sulfuric acid and then filtered.

The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution for complete reaction.

Calculate the percentage by mass of iron(II) carbonate in the sample of spathose. [3]

(b) The following table compares the pK_a values of malonic acid, a dicarboxylic acid with that of propanol and propanoic acid.

acid	formula	pK_1	pK_2
malonic acid	$HO_2CCH_2CO_2H$	2.83	5.69
propanol	$CH_3CH_2CH_2OH$	16.1	–
propanoic acid	$CH_3CH_2CO_2H$	4.88	–

(i) Explain why the pK_a value for propanoic acid is smaller than the pK_a of propanol. [2]

(ii) Explain why the pK_1 value is smaller than the pK_2 for malonic acid. [1]

The monosodium salt of malonic acid is added to some foodstuffs as buffers.

(iii) Explain what is meant by the term *buffer solution*. [1]

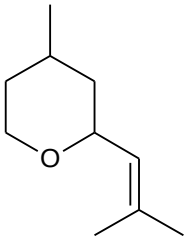
(iv) Write two equations to show how monosodium malonate, $HO_2CCH_2CO_2^-Na^+$, acts as a buffer. [2]

(c) Separate samples of Na_2O and P_4O_{10} were added to water.

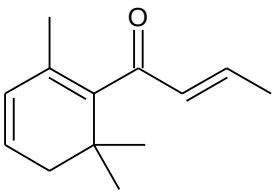
(i) For each oxide, write a balanced equation for its reaction with water and suggest a numerical value for the pH of the resulting solution. [4]

(ii) Construct a balanced equation for the reaction that occurs when a solution of Na_2O in water reacts with a solution of P_4O_{10} in water. [1]

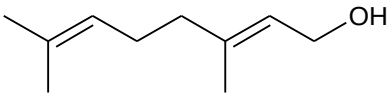
(d) Rose oil is extracted from the petals of various types of rose. It contains the following organic compounds.



rose oxide



damascenone



geraniol

Describe two chemical tests that would allow you to distinguish between separate unlabelled samples of rose oxide, damascenone, geraniol. State what you would observe in each test, for each compound. Write equations for each positive test. [6]

[Total: 20]

6 Iodine and chlorine are commonly used for chemical purification of water outdoors.

(a) Iodine treatment of water involves the use of iodine tincture. It is usually made up of 2-7% elemental iodine with sodium iodide, dissolved in a mixture of ethanol and water. When sodium iodide is added with elemental iodine in water, an equilibrium is established and triiodide ions are formed.

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

Chlorine treatment of water involves the use of tablets that contain sodium chlorite(III), $NaClO_2$. When sodium chlorite(III) dissolves in water, chlorine dioxide, ClO_2, which is a radical is formed. It is an effective disinfectant against most waterborne pathogenic agents.

(i) Draw the dot-and-cross diagrams of I_3^- ion and ClO_2 molecule. Use the Valence Shell Electron Pair Repulsion (VSEPR) theory to state and explain the shape of the species. [4]

(ii) Elemental iodine has low solubility in water. Sodium iodide is added to increase its solubility.

Explain why the triiodide ion formed is more soluble in water. Draw a labelled diagram to show how a water molecule can be attached to a triiodide ion and the type of interaction involved. [2]

(iii) The enthalpy change of vaporisation of chlorine dioxide is less endothermic than elemental iodine. Explain why. [2]

(b) **(i)** Define, with an equation, the first ionisation energy of chlorine. [2]

(ii) Explain why the first ionisation energy of iodine is lower than the first ionisation energy of chlorine. [2]

(iii) Sketch the trend of first ionisation energy across Period 3 and account for any anomaly to the general trend. [5]

(c) Hydrocarbon undergoes reactions with chlorine under different conditions.

Suggest the structures of the products formed when the following hydrocarbons react under different conditions with chlorine.

(i) butane with chlorine gas in the presence of uv light [1]

(ii) but-1-ene with chlorine gas in the dark [1]

(iii) methylbenzene with chlorine gas and anhydrous aluminium chloride [1]

[Total: 20]

7 **(a)** **(i)** Using the chlorides of magnesium, silicon and phosphorus as examples, describe their reactions, if any, with water. Explain the trend in the pH of the solutions formed. Write balanced equations for any reactions that take place. [4]

(ii) Suggest how the type of bonding present in these three chlorides affect their reaction with water. [1]

(b) Hydrogen peroxide decomposes in the presence of iodide ions according to the following equation.

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$

To study the kinetics of the above reaction, a 80 cm^3 mixture containing the following was prepared.

- 30 cm^3 of 0.100 mol dm^{-3} of H_2O_2
- 30 cm^3 of 1.00 mol dm^{-3} of iodide ions
- 20 cm^3 distilled water

At every five minutes interval, 10.0 cm^3 samples were removed and 50 cm^3 of cold water was added, followed by a titration against a solution of fixed concentration of potassium manganate(VII).

The experiment was repeated using 2.00 mol dm^{-3} of iodide ions.

The following results were obtained.

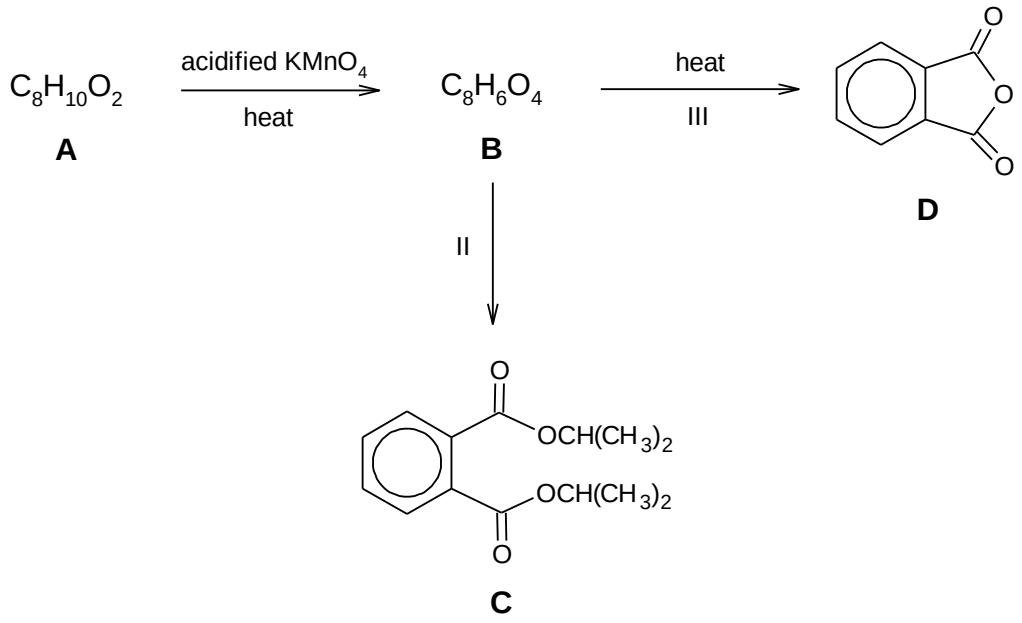
Experiment	Time/min	0	5	10	15	20	25
1	Volume of $KMnO_4$ / cm^3 when [iodide ions] = 1.00 mol dm^{-3}	30.00	20.00	15.00	11.00	7.50	5.00
2	Volume of $KMnO_4$ / cm^3 when [iodide ions] = 2.00 mol dm^{-3}	30.00	15.00	7.50	3.75	1.875	0.938

(i) Explain why 50 cm^3 of cold water was added prior to the titration. [1]

(ii) Plot a graph of these results, putting all the data on the same axes. Label each curve clearly. [1]

(iii) Use your graph to deduce the order of reaction with respect to hydrogen peroxide and iodide ions. Hence, write a rate equation for this reaction and state the units of the rate constant. [5]

(c) **(i)** Suggest structures for compounds **A** and **B** in the following scheme, explaining all the reactions involved. Hence, write a balanced equation for the conversion from **A** to **B**.



A **B** **D** **C**

[4]

(ii) State the type of reaction, and reagents and conditions for reaction II. [2]

(iii) Describe a simple chemical test that would allow you to distinguish between compounds **C** and **D**. [2]

[Total: 20]

2017 J2 H1 Chemistry Prelim Answers

Paper 1 Answer Key

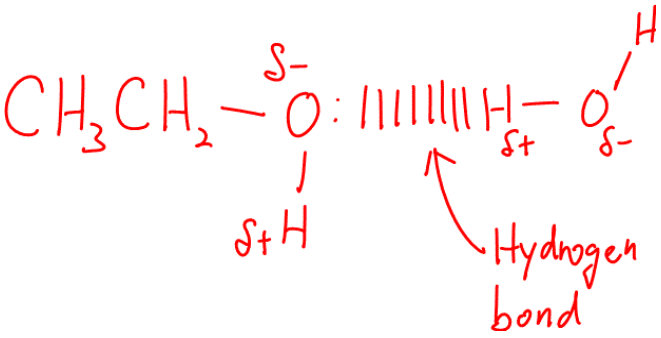
1	**B**	6	**A**	11	**A**	16	**D**	21	**A**	26	**C**
2	**C**	7	**B**	12	**B**	17	**A**	22	**D**	27	**B**
3	**D**	8	**C**	13	**C**	18	**C**	23	**D**	28	**A**
4	**D**	9	**B**	14	**A**	19	**A**	24	**C**	29	**B**
5	**C**	10	**B**	15	**B**	20	**D**	25	**D**	30	**C**

Paper 2 Section A Answers

1 (a) (i) The carbon-carbon single bond in the ethane molecule consists of 1 π bond. The carbon=carbon double bond in ethane molecule consists of 1 σ bond and 1 π bond.

A π bond is weaker than a σ bond due to less effective overlap, hence C=C bond is less than twice of C-C bond.

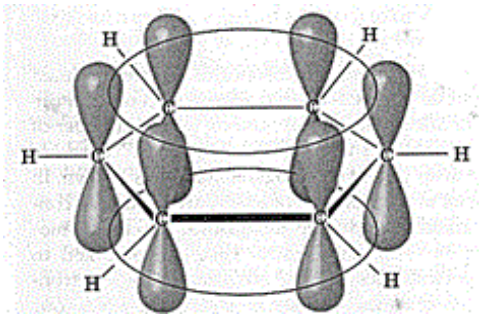
(ii)



(iii) Ethanol and butanol differs in the size of the non-polar hydrocarbon chain.

Butanol is insoluble in water even though it can form hydrogen bonds with water. Its predominantly forms dispersion forces with water due to its long, non-polar hydrocarbon chain. The energy released during formation of these dispersion forces is not enough to overcome the hydrogen bonds between water molecules and the dispersion forces between butanol.

(b) (i)



(ii) The delocalised π electron cloud results in stability, so the loss of this aromatic character is not energetically favored. Instead, benzene tends to undergo substitution reactions so that its π electron cloud remains intact to maintain aromatic stability.

(iii) Benzene do not undergo oxidation.

Methylbenzene is oxidized by heating with $KMnO_4$, H_2SO_4 (aq)

(c) Bond energy of C-H bond = 410 kJ mol^{-1}
Bond energy of C-Cl bond = 340 kJ mol^{-1}

As fluorine atom is smaller than chlorine, bond length of C-F bond is shorter than C-Cl bond. Therefore C-F bond is expected to be stronger than C-Cl bond, hence they do not break easily to form free fluorine atoms to attack the ozone layer.

2 (a) (i) $CrO_4^{2-} + 8H^+ + 3e \rightarrow Cr^{3+} + 4H_2O$

(ii) Amount of electrons gained by 0.0150 mole of CrO_4^{2-} = 0.0450 mol
Amount of electrons lost by 0.0225 mole of SO_2 = 0.0450 mol
Therefore each mole of SO_2 lost = (0.0450/0.0225) = 2 mol of electron

Original oxidation number of sulfur = +4
New oxidation number of sulfur = +4 + 2 = +6

(iii) SO_4^{2-}

(b) (i) $K_c = \dfrac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2[H^+]^2}$

(ii) Amount of $PbCrO_4$ initiallly = 20.00/ (207.2+52.0 +16.0x4)
= 0.06188 mol
$[CrO_4^{2-}]$ initially = 0.06188/(100/1000) = 0.6188 ≈ 0.619mol dm^{-3}

(iii) $[CrO_4^{2-}]$ at equilibrium = 0.6188 / 5 = 0.1237 = 0.124 mol dm^{-3}

$[Cr_2O_7^{2-}]$ at equilibrium = $\dfrac{0.6188 - 0.1237}{2}$
= 0.2475 ≈ 0.248 mol dm^{-3}

(iv) Since K_C = 7.55 x 10^{12} mol^{-3} dm^9

$[H^+] = \sqrt{\dfrac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2 \times Kc}} = \sqrt{\dfrac{0.2475}{0.1237^2 \times 7.55 \times 10^{12}}} = 1.463 \times 10^{-6}$ mol dm^{-3}

pH = 5.8

(v) By Le Chatelier's Principle, the system will react to reduce the added amount of NaOH. Backward reaction is favoured and position of equilibrium shifts to the left. [1] The solution will appear yellow in color due to formation of aqueous CrO_4^{2-}.

3 (a) Place a lighted splint near the mouth of the test tube. A pop sound would be heard to confirm its identity as hydrogen gas.

(b) (i) From orange to green

(ii) Oxidation

(c) (i) X: $CH_3CH_2CH_2OH$ Y: CH_3CH_2CHO

(ii) $CH_3CH_2CHO + 2Cu^{2+} + 5OH^- \rightarrow CH_3CH_2CO_2^- + Cu_2O + 3H_2O$

(iii) Test: Add Tollens' to solution and warm.
Observation: Silver mirror observed with Y. No silver mirror with X.

Test: Add 2,4-DNPH to solution and warm
Observation: orange precipitate formed with Y. No orange precipitate with X.

4 (a) Energy change when one mole of a substance is completely burnt in excess oxygen under standard conditions.

(b) (i) Carbon: $C(s) + O_2(g) \rightarrow CO_2(g)$
Methane: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

(ii) 1 MJ = 10^6 J = 1000 kJ

Since ΔH_C (C) = - 394 kJ mol^{-1}, amount of carbon need to be burned to produce 1 MJ of heat = 1000 / 394 = <u>2.54 mol</u>

Since ΔH_C (CH_4) = - 890 kJ mol^{-1}, amount of methane need to be burned to produce 1 MJ of heat = 1000 / 890 = <u>1.12 mol</u>

(iii) Since efficiency of coal power station = 40% , amount of carbon need to be burned to produce 1 MJ of heat = 2.538 / 0.40 = <u>6.35 mol</u>

Since efficiency of natural gas power station = 51% , amount of methane need to be burned to produce 1 MJ of heat = 1.124 / 0.51 = <u>2.20 mol</u>

(c) Mass of C (s) need to be burn to produce 1 MJ of electrical energy = 6.35 x 12.0 = 76.2 g
Mass of ash produced = 76.2 (5/95) = 4.01 g

(d) (i) CO_2 is a <u>greenhouse gas</u> that causes <u>global warming</u>, leading to <u>droughts and rising sea levels</u>.

(ii) Coal is found in the solid state, which is easier to store and transport. Hence it is easier and cheaper to operate power station that burn natural gas which is harder to store and transport.

(e) (i) Amount of methane need to be burned to produce 1 MJ of heat = 1.124 mol
Volume of methane at rtp = 1.124 x 24.0 = 27.0 dm^3

(ii) $CO + ½ O_2 \rightarrow CO_2 \quad \Delta H_C = -283$
$H_2 + ½ O_2 \rightarrow H_2O \quad \Delta H_C = -242$
Since 1 mole of water-gas contain ½ mole of CO and ½ mole of H_2, amount of heat energy produced by 1 mole of water-gas
= ½ (283) + ½ (242) = 262.5 kJ
Therefore amount of water-gas needed to produce 1 MJ of heat energy = 1000/262.5 = 3.810 mol
Volume of water-gas at rtp = 3.810 x 24.0 = 91.4 dm^3

(iii) - Volume of methane needed to be burn to produce 1 MJ is lower, hence it is safer and easier to operate a power station using natural gas.

Paper 2 Section B Answers

5 (a) $n(MnO_4^-) = 0.0200 \times 27.30 / 1000 = 5.46 \times 10^{-4}$ mol

$n(Fe^{2+})$ in 25.0 $cm^3 = 5.46 \times 10^{-4} \times 5 = 2.73 \times 10^{-3}$ mol

$n(Fe^{2+})$ in 250 $cm^3 = 2.73 \times 10^{-3} \times 250 / 25.0 = 2.73 \times 10^{-2}$ mol

mass of $FeCO_3 = 2.73 \times 10^{-2} \times 115.8 = 3.161$ g

percentage by mass of $FeCO_3 = 3.161 / 5.00 \times 100\% = 63.2\%$

(b) (i) $CH_3CH_2CH_2O^-$ is the <u>least stable</u> as the <u>electron donating alkyl ($-CH_2CH_2CH_3$) group</u> on the $CH_3CH_2CH_2O^-$ ion increases the electron density on the oxygen atom, <u>making it even more negative</u>, hence <u>destabilising the $CH_3CH_2CH_2O^-$ ion</u>. Thus propanol is less acidic than propanoic acid.

$CH_3CH_2COO^-$ is the most stable as the <u>p orbital of the oxygen atom overlaps with the π electron cloud of the –C=O bond</u> and the <u>lone pair of electrons on the oxygen atom delocalise into the –C=O</u>. The negative charge is dispersed over the carbon atom and the two electronegative oxygen atoms, stabilising the $CH_3CH_2COO^-$ ion. Thus propanoic acid is more acidic than propanol.

(ii) It is more difficult to remove a proton from an anion.

(iii) A buffer solution is a solution that is able to maintain a **fairly constant** pH when a **small** amount of acid or base is added.

(iv) $HO_2CCH_2CO_2Na + H^+ \rightarrow HO_2CCH_2CO_2H + Na^+$
$HO_2CCH_2CO_2Na + NaOH \rightarrow NaO_2CCH_2CO_2Na + H_2O$

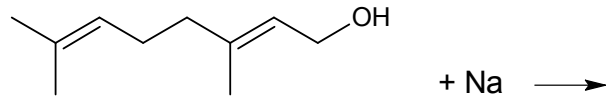
(c) **(i)** $Na_2O\ (s) + H_2O\ (l) \rightarrow 2NaOH\ (aq)$
pH = 13

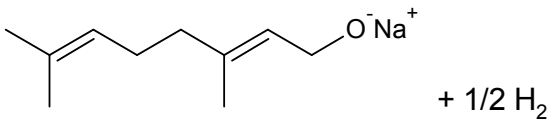
$P_4O_{10}\ (s) + 6H_2O\ (l) \rightarrow 4H_3PO_4\ (aq)$
pH = 1-2

(ii) $H_3PO_4\ (aq) + 3NaOH\ (aq) \rightarrow Na_3PO_4\ (aq) + 3H_2O\ (l)$

(d) 1. Sodium metal at room temp

Geraniol will give effervescence. H_2 (g) evolved gives a 'pop' sound with a lighted splint.

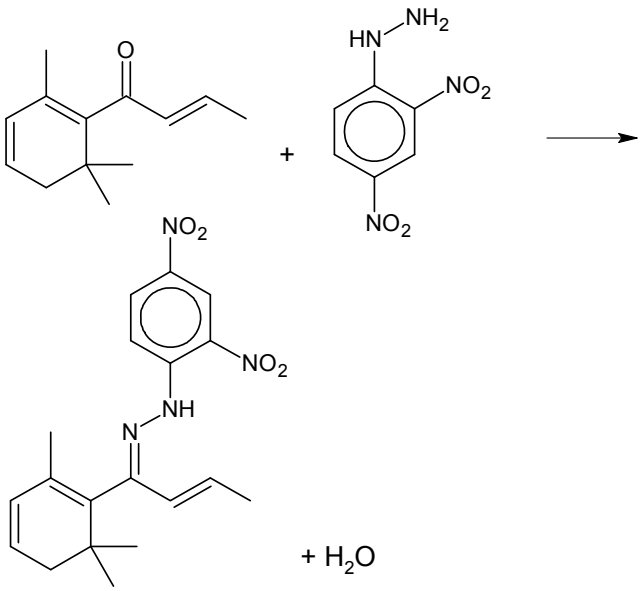




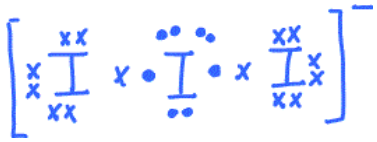
Rose oxide and damascenone will not give any effervescence. No 'pop' sound with a lighted splint observed.

2. 2,4-DNPH, warm

Damascenone will give an orange precipitate but not rose oxide, geraniol.



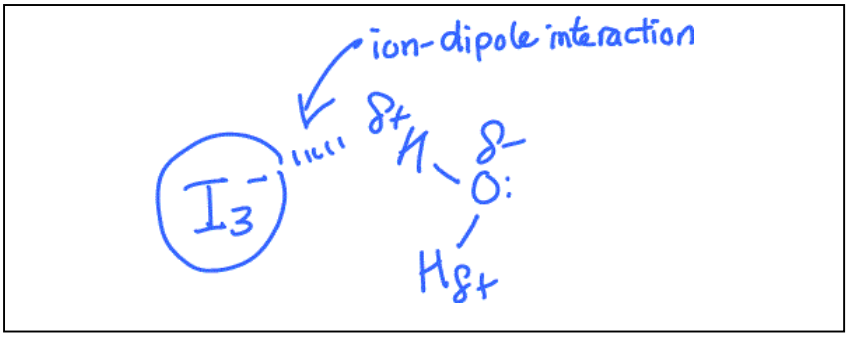
6 (a) (i)

	I_3^-	ClO_2
Dot-and-cross diagram		

I_3^- has 2 bond pairs and 3 lone pairs. The electron pairs will orientate as far as possible to minimise repulsion. Since the repulsion between lone pair – lone pair > bond pair – lone pair > bond pair – bond pair, the shape with respect to I atom is linear.

ClO_2 has 2 bond electron domains, 1 lone pair and 1 lone electron. The electron pairs will orientate as far as possible to minimise repulsion. Since the repulsion between lone pair – lone pair > bond pair – lone pair > bond pair – bond pair, the shape with respect to *Cl* atom is bent.

(ii)



The <u>energy released</u> when the <u>H_2O molecules formed the stronger ion-dipole interaction with I_3^- ions</u> is sufficient to overcome the hydrogen bonds between the H_2O molecules.

(iii) Both I_2 and ClO_2 have simple molecular structure with weak dispersion forces between molecules . The size of electron cloud for ClO_2 is smaller, hence less polarisable. The dispersion forces between ClO_2 molecules is weaker. Less energy is needed to overcome the weaker dispersion forces, enthalpy change of vaporisation for ClO_2 is less endothermic.

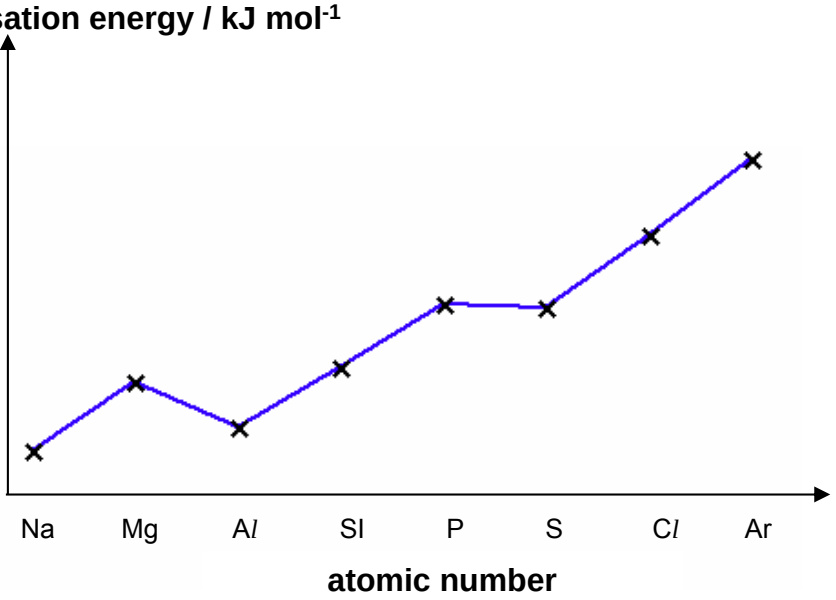
(b) (i) The first ionisation energy of chlorine is the energy required to remove one mole of electrons from one mole of gaseous Cl atoms to form one mole of singly charged gaseous Cl cations.

$Cl(g) \downarrow Cl^+(g) + e$

.

(ii) Down a group, the number of protons increases, the nuclear charge increases. As the number of electron shells increases, the shielding effect increases significantly for iodine. The increase in shielding effect outweighs the increase in nuclear charge, effective nuclear charge decreases. Less energy is needed to remove the outermost electron, hence iodine has a lower first ionisation energy.

(iii)



Between Mg (Group 2) and Al (Group 3)
Mg $1s^2\ 2s^2\ 2p^6\ 3s^2$
Al $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

First ionisation of Al is lower than that of Mg.
Less energy is required to remove the 3p electron in Al as it experiences increased shielding by the filled 3s subshell.

Between P (Group 15) and S (Group 16)
P $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1$

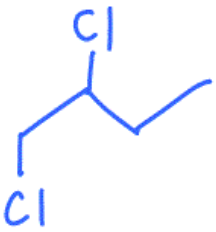
S $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^2\ 3p_y^1\ 3p_z^1$

First ionisation of S is lower than that of P.
Less energy is required to remove the paired $3p_x$ electron in S as it experiences interelectronic repulsion arising from 2 electrons occupying the same 3p orbitals.

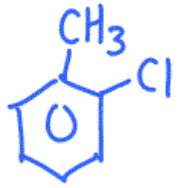
(c)

(i)

(ii)



(iii)



OR

7 (a) (i) $MgCl_2$ undergoes hydration with water to from aqueous Mg^{2+} and Cl^- ions.
$[Mg(H_2O)_6]^{2+}$ then undergoes slight hydrolysis with water to produce H_3O^+ hence a weakly acidic solution is formed. pH = 6.5

$MgCl_2$ (s) + $6H_2O$(l) → $[Mg(H_2O)_6]^{2+}$(aq) + $2Cl^-$(aq)

$[Mg(H_2O)_6]^{2+}$ (aq) + H_2O(l) ⇌ $[Mg(H_2O)_5OH]^+$ (aq) + H_3O^+

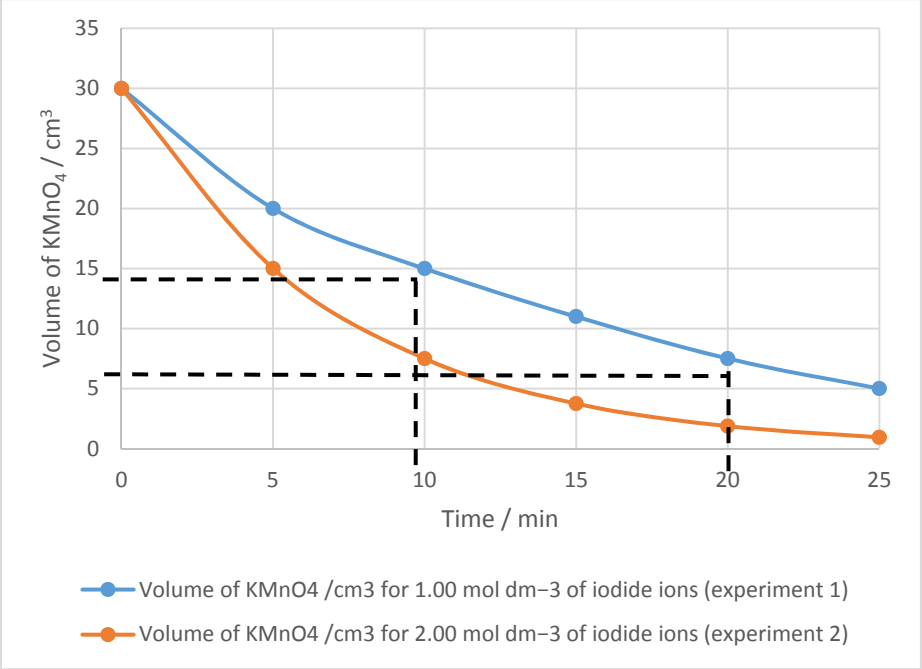
Both $SiCl_4$ and PCl_3 (or PCl_5) undergoes hydrolysis with water to from a strongly acidic solution, pH = 1 – 2.

$SiCl_4$ (l) + 2 H_2O (l) →SiO_2 (s) + 4 HCl (aq)
PCl_3 (l) + 3 H_2O (l) → H_3PO_3 (aq) + 3 HCl (aq)
OR PCl_5 (l) + 4 H_2O (l) → H_3PO_4 (aq) + 5 HCl (aq)

(ii) $MgCl_2$ is an ionic chloride hence it undergoes hydration to form the ions readily while both $SiCl_4$ and PCl_3 (or PCl_5) are covalent chlorides which undergoes hydrolysis with water.

(b) (i) 50 cm^3 of cold water was added prior to the titration to stop/slow down the reaction so as to achieve a more accurate titre value at that time / to find the concentration at that instance.

(ii)



(iii) When volume of $KMnO_4$ decreases from 30 cm^3 to 15 cm^3, time taken is 10 min.
When volume of $KMnO_4$ decreases from 15 cm^3 to 7.5 cm^3, time taken is 10 min.
Since the 2 half lives are approximately constant at 10 min, reaction is first order to $KMnO_4$.

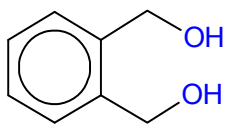
Since volume of H_2O_2 and concentration of $KMnO_4$ are constant, $[H_2O_2]$ is proportional to $V(KMnO_4)$. Reaction is thus first order with respect to H_2O_2.
When $[I^-]$ = 1.00 mol dm^{-3}, initial rate = 30/6.5 = 4.62 cm^3 min^{-1}
When $[I^-]$ = 2.00 mol dm^{-3}, initial rate = 30/11.5 = 2.61 cm^3 min^{-1}

As $[I^-]$ doubles (2/1), initial rate also doubles (4.62/2.61 ≈ 2), hence order of reaction with respect to I^- is one.

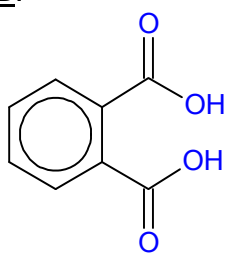
Rate = $k[H_2O_2][I^-]$
Units for rate constant: mol^{-1} dm^3 min^{-1}

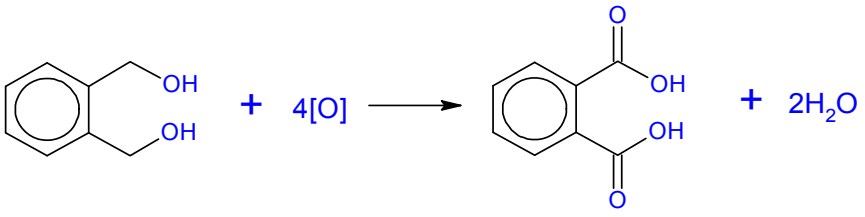
(c) (i) The primary alcohol in A undergoes oxidation with acidified KMnO4 to form carboxylic acid in B.

A:



B:





(ii) Type of reaction: Condensation
Reagents & conditions: $CH(CH_3)_2OH$, conc. H_2SO_4, heat under reflux

(iii) Reagent and condition: I_2(aq), NaOH(aq), warm
Observations for **C**: Yellow ppt of CHI_3 formed.
Observations for **D**: No yellow ppt of CHI_3 formed.