SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

Candidate Name

Class

CHEMISTRY **8872/02**

Preliminary Examination **22 August 2014**
Paper 2 **2 hours**

Candidates answer Section A on the Question Paper
Additional Materials: Answer Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in black or dark blue pen.
You may use a pencil for any diagrams, graphs or rough working.

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

Section A
Answer **all** the questions.

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

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

At the end of the examination, fasten all your work securely together.

Section A and Section B are to be handed in separately.
Please attach cover page for Section B.

FOR EXAMINER'S USE		
P1 (MCQ)		/30
P2 Section A	1	/12
	2	/8
	3	/8
	4	/6
	5	/6
P2 Section B (3 choose 2)	6	/20
	7	/20
	8	/20
Total		/110

This document consists of 17 printed pages and 3 blank pages.

Section A

Answer **ALL** questions

For Examiner's Use

1 **(a)** The greenhouse effect is an energy-trapping process in which the infra-red radiation reflected from the Earth's surface is absorbed by greenhouse gases (primarily CO_2 and H_2O) and re-radiated back towards Earth. This is a natural phenomenon which helps to keep the earth comfortably warm.

The increase in the amount of CO_2 in the atmosphere has been largely attributed to an increase in human consumption of energy. The global power consumption was estimated to be 7×10^{11} W (watts) in 1900.

In 2004, with a global population about 6×10^9, the global power consumption has risen to 15×10^{12} W with 86% of the energy supplied by burning fossil fuel such as coal, oil and natural gases.

The global carbon dioxide emission from consumption of coal is 10590 million tonnes in 2004. The global population is expected to hit 9×10^9 in 2050.
(1 tonne = 1000 kg)

Concerns over the effects of global warming have led to various actions by government bodies and individuals to avert what is perceived as a potential global disaster. Such actions include bills to reduce industrial emissions of CO_2, worldwide concerts spreading the message on global warming and products designed to reduce electrical consumptions.

An example is the use of compact florescent light (CFL) in place of the incandescent light bulb. The CFL consumes only 3.2×10^{-2} kW of power per hour as compared to the 1.5×10^{-1} kW which the incandescent light bulbs consume. This not only translates to savings for the user, more importantly, it helps to reduce electrical consumption and CO_2 emissions.

(i) Use the data above to find the average power consumption per person for the year 2004.

For Examiner's Use

(ii) Estimate the mass of fossil fuel that has to be burnt to meet a person's power consumption in the year 2004, assuming that burning 300 kg of fossil fuel is enough to generate 1000 W of power.

(iii) Calculate the average carbon dioxide emission per person in 2004.

Assuming that the average carbon dioxide emission per person remains unchanged, hence, estimate the total coal consumption (in kilograms) for the year 2050.

(Assume coal is 100% carbon.)

(iv) Based on an average usage of 6 hours per day, determine how much you can save each day if you use a CFL instead of an incandescent light bulb.
(PUB charges $0.188 per kW per hour)

[6]

(b) Propanic acid is found in trace amount in diesel oil. The acid dissociation constant, K_a, for propanoic acid has the value of 1.35×10^{-5} mol dm^{-3} at 25 ^{o}C.

For Examiner's Use

$$K_a = \frac{\left[H^+\right]\left[CH_3CH_2CO_2^-\right]}{\left[CH_3CH_2CO_2H\right]}$$

(i) Given that $[H^+] = [CH_3CH_2CO_2^-]$, find the pH of a 0.117 mol dm^{-3} aqueous solution of propanoic acid.

(ii) Calculate the degree of ionisation of propanoic acid.

(iii) A buffer solution is formed by mixing propanoic acid and sodium propanoate.

Explain, using suitable equations, how this buffer solution works to maintain fairly constant pH upon the addition of small amounts of H^+ and OH^- separately.

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(iv) Two drops of an indicator was added to 25 cm^3 of the above mentioned buffer solution. When excess NaOH(aq) was added, the indicator changed colour.

Suggest a value for the end point pH and hence, a suitable indicator.

……

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[6]

[Total: 12]

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For Examiner's Use

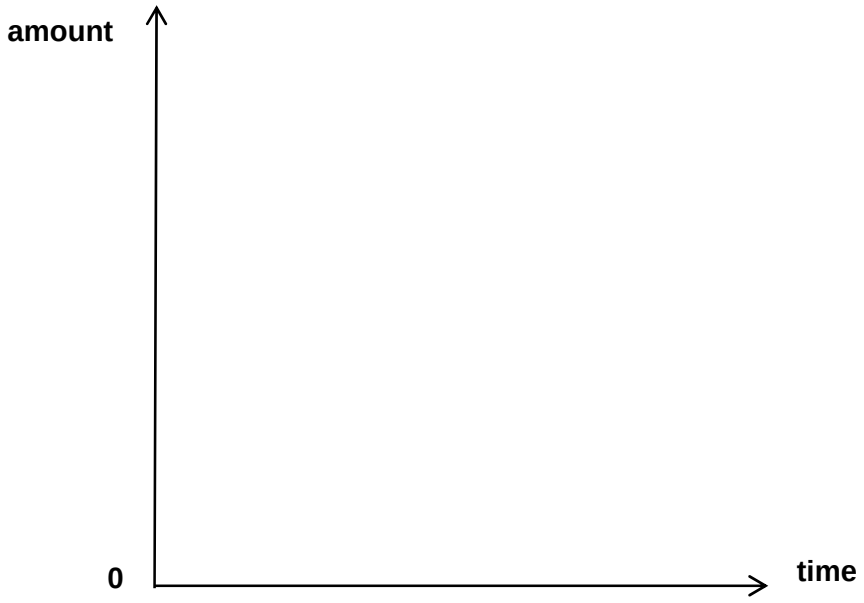
2 The decomposition of nitrosyl chloride, NOC*l* at 227 ^{o}C is shown below:

$$2\ NOCl(g) \rightleftharpoons 2\ NO(g) + Cl_2\ (g)$$

(a) (i) Write an expression for the equilibrium constant K_c for this reaction.

(ii) A 2.6 mol of NOC*l* was placed in a 2 dm^3 reactor and heated to 227 ^{o}C until the system reached equilibrium. It was found that 0.8 mol of NO was present at equilibrium. Calculate the K_c of the reaction.

(iii) Sketch and label, in the axes below, the amount of reactants and products from the start of the reaction to some time after equilibrium is established.



[6]

(b) When the temperature of the system at equilibrium was increased, the colour of the greenish yellow gas intensified.

For Examiner's Use

$$2\ NOCl(g) \rightleftharpoons 2\ NO(g) + Cl_2\ (g)$$

Deduce if the enthalpy change of decomposition of NOC*l* is endothermic or exothermic. Explain your answer.

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[2]

[Total : 8]

For Examiner's Use

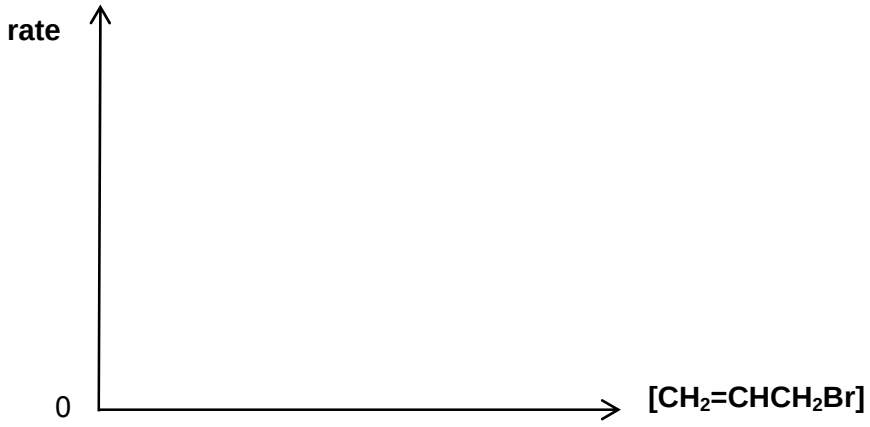
3 3-bromopropene can be hydrolysed by aqueous sodium hydroxide to form alcohols.

Four sets of experiments were carried out to investigate the kinetics of this reaction:

Experiment	**[CH_2=$CHCH_2Br$] / mol dm^{-3}**	**[NaOH] / mol dm^{-3}**	**Relative initial rate**
1	0.10	0.20	1.00
2	0.20	0.10	2.00
3	0.30	0.20	3.00
4	0.60	0.40	6.00

(a) (i) Use the data in the table to deduce the order of reaction with respect to CH_2=$CHCH_2Br$ and NaOH.

(ii) Sketch a graph of rate against [CH_2=$CHCH_2Br$] in the axes below.

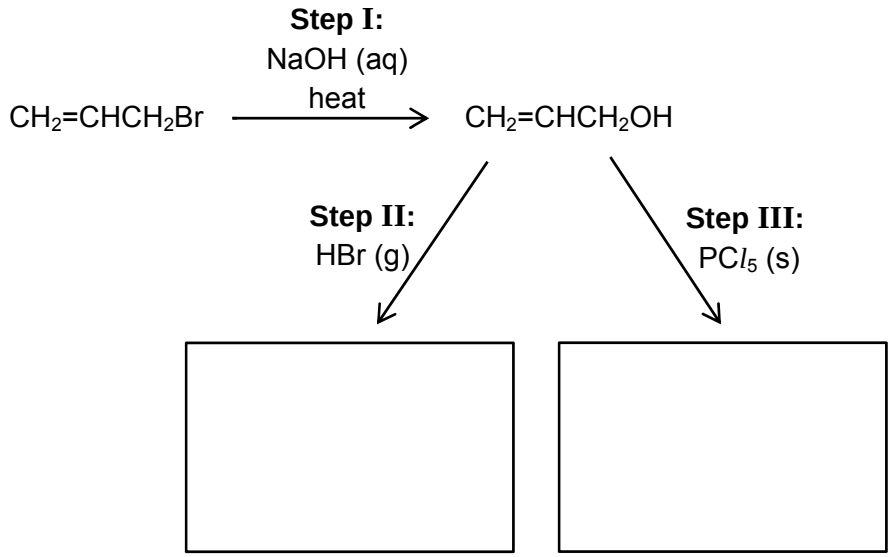


For Examiner's Use

(iii) Given that the time taken for 75.0% of CH_2=$CHCH_2Br$ to be used up is 10 minutes, calculate the time taken for 87.5% of CH_2=$CHCH_2Br$ to be used up in the reaction.

[5]

(b) (i) Alcohols may also be converted back to halogeno compounds. In the reaction scheme illustrating this process below, fill in the major organic products formed upon reaction.



(ii) By writing a chemical equation, illustrate why phosphorus pentachloride used in Step **III**, must be anhydrous.

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[3]

[Total: 8]

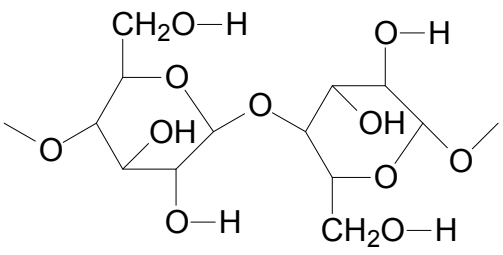
4 Cellulosic materials include cotton, rayon, and linen, all of which are very polar and hydrophlilic.

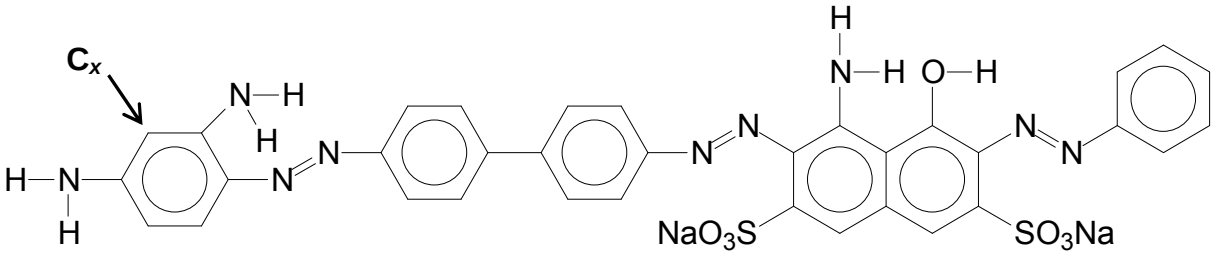
For Examiner's Use

Such materials require polar, water–soluble dyes for their colouration from a dyebath. In addition, dyes must be designed that maintain affinity when the cellulosic substrate is exposed to water.

The diagram below shows a fragment of cellulose **A** and direct dye **B**.

cellulose **A**





direct dye **B**

(a) Describe how the hybridised state of C_x is formed.

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……

[2]

(b) (i) Name the functional group that is present in cellulose **A**.
You may ignore the –C–O–C– functional group.

……

(ii) Describe a chemical test which shows a positive result for alkenes but not the functional group identified in **(b)(i)**.

For Examiner's Use

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……

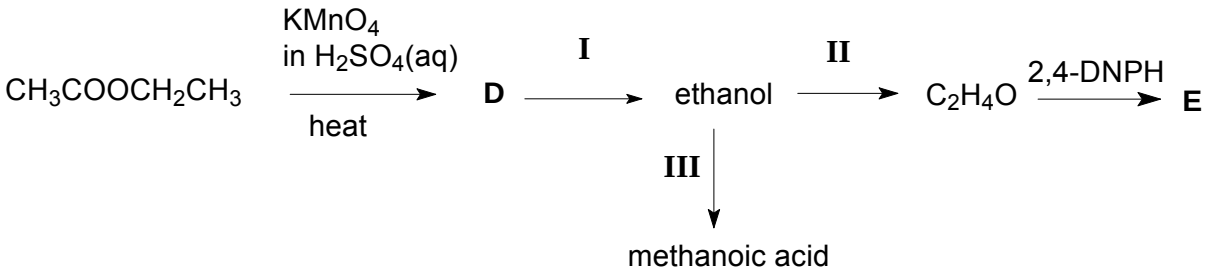
[3]

(c) Hydrogen bonding was found to exist between cellulose **A** and direct dye **B**.
Draw on the diagram on **page 10** to show **one** hydrogen bond.

[1]
[Total: 6]

5 Ethyl ethanoate is commonly found in artificial fruit essences and aroma enhancers.

The reaction scheme shows reactions involving ethyl ethanoate.



(a) Draw the structural formulae for compounds **D** and **E**.

D	E

[2]

(b) State the reagents and conditions for reactions **I**, **II** and **III**.

Reaction **I**: _____

Reaction **II**: _____

Reaction **III**: _____ **[3]**

(c) Suggest a reagent to test for the presence of methanoic acid.

……..

[1]

[Total: 6]

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Section B

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

6 Compounds of sulfur have many uses in our everyday life, such as in disinfectants, matches and in the making of paper.

(a) Phosphorus sulfide, P_4S_3, is used in small amounts in the tip of a match stick. On striking a match stick, this compound burns to form sulfur dioxide and a solid oxide.

(i) Construct an equation for this reaction.

(ii) The melting point of sulfur dioxide differ significantly from that of silicon (IV) oxide, SiO_2.
Briefly relate this observation to the structure and bonding in each of the oxides.

(iii) Sulfur dioxide formed in **(a)(i)** dissolves in water to give acidic an solution. Construct an equation for the reaction of sulfur dioxide with water and give an approximate pH for the solution formed.

[5]

(b) Compounds of sulfur can also be used in organic synthesis. But–2–ene can be synthesised from but–1–ene via a 2–step reaction scheme as shown below.

$$CH_3CH_2CH{=}CH_2 \xrightarrow{\mathbf{I}} CH_3CH_2CH(OH)CH_3 \xrightarrow{\mathbf{II}} CH_3CH{=}CHCH_3$$

(i) Describe the reagents and conditions necessary for reaction **II**.

(ii) But–2–ene occurs in two isomeric forms but cyclobutene occurs in only one form.

Draw the displayed formulae and state the geometry of two isomers.
Explain why such isomerism is not possible with cyclobutene.

(iii) An isomer of but–2–ene gives only one monobrominated product with Br_2 under ultraviolet light.

Suggest the structural formula of this isomer.

But–2–ene, on treatment with cold concentrated H_2SO_4 followed by the addition of hot water, gives an addition product **J**, $C_4H_{10}O$. **J** produces a yellow precipitate on warming with alkaline aqueous iodine.

J turns orange hot acidified potassium dichromate green. The organic product, **K**, formed is then reacted with HCN to give compound **L**, C_5H_9NO.

Treatment of **L** with hot dilute sulfuric acid gives compound **M**. 0.590 g of **M** (M_r = 118.0) reacts with excess sodium metal to give 120 cm^3 of hydrogen gas (measured at room temperature and pressure).

On heating in the absence of air, **M** loses water to give a single compound **N** ($C_{10}H_{16}O_4$). **N** no longer reacts with sodium metal.

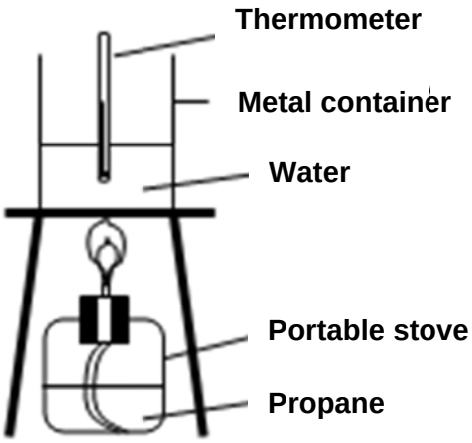
(iv) Deduce the structures of compounds **J**, **K**, **L**, **M** and **N** and explain the chemistry of the reactions described.
[There is no need to comment on the chemistry of the formation of **J** from but–2–ene.]

[15]
[Total: 20]

7 Propane is used in blow torches, portable stoves and in outdoor heaters.

The theoretical standard enthalpy change of combustion of propane is −2220 kJ mol^{-1}.

(a) A propane portable stove was used during a barbecue to boil water. It took 10 minutes to boil the water.



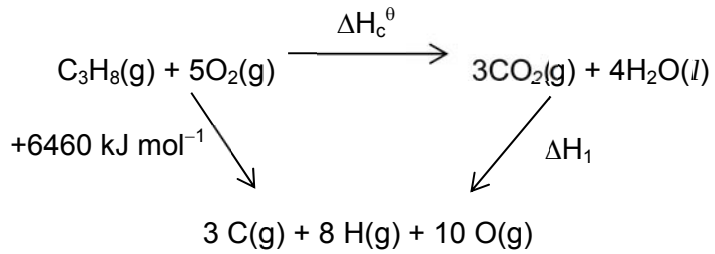
The following information was known.

Mass of metal container / g	850
Mass of metal container containing water / g	1600
Initial temperature of water / °C	32

(i) Define the term *standard enthalpy change of combustion* of propane.

(ii) Calculate the mass of propane needed to boil the water during the barbecue.

(iii) Another value of the standard enthalpy change of combustion of propane, ΔH_c^{θ}, can be calculated using bond energies and the energy cycle below.



Use suitable bond energies given in the *Data Booklet* to calculate ΔH_1.

(iv) Hence, calculate ΔH_c^{θ}.

(v) Suggest why the value of ΔH_c^{θ} calculated in **a(iv)** differs from the theoretical value.

[7]

(b) Besides being used as fuel, propane can also be used to synthesise other organic compounds.

(i) Outline a three step synthesis of 1-aminobutane, $CH_3CH_2CH_2CH_2NH_2$, from propane. State clearly the reagents and conditions used and draw any intermediate products formed.

(ii) Describe a chemical test, other than redox, to distinguish between propane and propan-1-ol.

(iii) State, with reasoning, whether propan-1-ol or 2-bromopropan-1-ol is a stronger acid.

(iv) 2-bromopropan-1-ol and 2-iodopropan-1-ol are reacted separately with hot aqueous potassium hydroxide followed by the addition of silver nitrate.

State the observations and explain the relative rate of reactions.

[10]

(c) Propane is a common feedstock and aluminium oxide is one of the possible catalyst used in the steam cracking process.

(i) Write equations for the reactions of aluminium oxide with aqueous sodium hydroxide and aqueous hydrochloric acid.

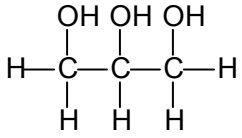
(ii) Derive the equation when beryllium metal reacts with aqueous sodium hydroxide, given that beryllium and aluminium shares a diagonal relationship in the periodic table.

[3]

[Total: 20]

8 Food additives are substances added to food to preserve its flavour or enhance its taste and appearance.

(a) In food and beverages, glycerol acts as food additive to keep food moist and may help to preserve foods.



Glycerol

Suggest, with reference to structure and bonding, how glycerol keeps food moist.

[1]

(b) Citric acid is a natural preservative and is also used to add a sour taste to food and drinks.

A sample of commercial powdered drink mix is analysed for the concentrations of citric acid and vitamin C (also known as ascorbic acid). 4.23 g of the powdered drink mix is dissolved in water and made up to 250 cm^3.

A 25.0 cm^3 aliquot requires 30.30 cm^3 of 0.200 mol dm^{-3} of sodium hydroxide for complete neutralisation.

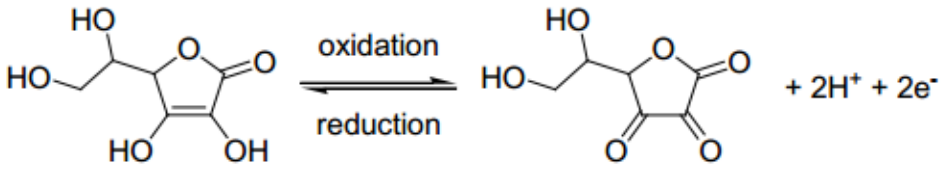
Citric acid, $C_3H_5O(COOH)_3$, is a triprotic acid and ascorbic acid, $C_6H_8O_6$ is a monoprotic acid. Their reactions with sodium hydroxide are as shown below:

$$C_3H_5O(COOH)_3\,(aq) + 3\,NaOH\,(aq) \rightarrow C_3H_5O(COO)_3Na_3\,(aq) + 3\,H_2O\,(l)$$

$$C_6H_8O_6\,(aq) + NaOH\,(aq) \rightarrow NaC_6H_7O_6\,(aq) + H_2O\,(l)$$

(i) Calculate the total amount of protons, H^+ present in 4.23 g of the powdered drink mix.

Ascorbic acid is a mild reducing agent with the following oxidation equation.



ascorbic acid dehydroascorbic acid

Another 25.0 cm^3 aliquot requires 34.70 cm^3 of 0.009 mol dm^{-3} iodine solution for complete redox reaction.

(ii) State the reacting ratio of ascorbic acid and iodine.

(iii) Calculate the amount of ascorbic acid present in the 4.23 g of the powdered drink mix.

(iv) Hence, calculate the mass of citric acid in the powdered drink mix.
(M_r of citric acid = 192.0)

[6]

(c) The process of preserving food with sulfur dioxide is intended to provide a longer shelf life. However, sulfur dioxide is also considered as a toxic gas and it may trigger asthma. Sulfur dioxide can be produced by the combustion of sulfur in oxygen.

The element sulfur has four naturally occurring isotopes.

isotope	Relative abundance / %
^{32}S	94.93
^{33}S	0.76
^{34}S	4.29
^{35}S	0.02

(i) Write the full electronic configuration of sulfur.

(ii) Sketch the trend of the successive ionisation energies of the first 10 electrons of a sulfur atom. Explain the shape of your sketch.

(iii) Define the term 'isotope'.

(iv) Use the relative abundance data to calculate the relative atomic mass of sulfur to 4 significant figures. Show your working.

(v) Draw the dot and cross diagram for SO_2 and the Lewis structure of SO_2, stating the shape of the molecule.

(vi) The bond angle of SO_2 is 119^o.
Hence, draw the dot and cross diagram of NO_2 and suggest, with reasoning, the O-N-O bond angle.

[13]
[Total: 20]

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