1996 HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY

In 1996 10 048 students presented for the examination in 2 Unit Chemistry. Although this represented a small decline in numbers for those of the previous year, it is, however, at a much smaller rate than that of the last five years.

General Comments

It was clear from the responses to parts of the paper that:

1. The correct Syllabus is being followed and the problems identified last year are not being repeated. Care will need to be taken in 1997 and 1998 that Syllabus changes are noted and suitable adjustments made to teaching problems.

2. Candidates gave good answers to questions based on mandatory experiences, indicating that schools are completing this part of the course. The standard of drawing of laboratory apparatus and some other diagrams was poor.

3. Students appeared to be giving prepared responses when they met some keywords, even though such a response might be irrelevant to the correct answer, or even contradictory. For example, the words *ionic bonds* produced the response *transfer of electrons* irrespective of the question.

4. Again, students are advised to give concise and relevant explanations rather than rambling answers.

   Students are advised to give a balanced chemical equation rather than a word equation when asked to write an equation for a reaction.

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SECTION I : CORE

PART A

Mean = 9.24				
Approximate percentage choosing each alternative				
Item	**A**	**B**	**C**	**D**
1	79*	13	4	4
2	18	50*	12	21
3	18	27	4	52*
4	3	9	82*	6
5	4	7	72*	18
6	11	15	14	59*
7	47*	13	19	21
8	57*	20	11	12
9	46	11	36*	7
10	96*	0	0	3
11	15	24	14	47*
12	22	49*	10	19
13	12	8	77*	3
14	25	10	13	52*
15	10	69*	15	7

* Correct response

3. This was a question of medium difficulty but 48% of candidates were unaware of weak dispersion forces between molecules.

9. In this difficult question nearly half of the students chose the alternative, which was the opposite of the correct answer. Such candidates either missed the word *increasing* in the stem of the question or did not understand K values.

12. This question was of medium difficulty but 41% of the students chose either a pH of 1 (as for a strong acid) or a pH value above 7 for an acid.

14. This was also a medium difficulty question but 25% of candidates thought that increasing the amount of water would shift the equilibrium to the right.

PART B

Question 16

(a) This was poorly answered by the majority of the students who were unable to give the correct formula for a stable oxide of sulfur, that is, the formula for either sulfur dioxide or sulfur trioxide.

(b) Most students were able to identify correctly the bonding between oxygen and sulfur as well as the bonding between oxygen and sodium.

(c) This was another poorly answered question as students did not know that sodium oxide formed a basic solution while stable oxides of sulfur formed acidic solutions. Some did not know the colour changes for litmus.

Question 17

Students were able to write correctly the equilibrium expression for the reaction of the two substances and to determine the number of moles for the reactants and products at equilibrium. A number of candidates used the maximum number of moles rather than the number of moles at equilibrium.

Many had difficulty in completing the final calculation of K correctly, as they failed to realise that the mixture was in a 2 litre container.

Question 18

A number of students found difficulty in distinguishing between the different forms of intermolecular forces and ionic bonds. Others were not skilled in drawing diagrams which correctly represented the *hydrogen bonding* between molecules.

(a) This question was poorly answered by the majority of students as they were unable to show clearly hydrogen bonding in either ammonia or ethanol.

(b) (i) This was generally well answered, although a number of students responded by writing either *sodium chloride* or *calcium oxide*.

(ii) This part was poorly answered as many students considered ionic bonds such as those found in sodium chloride and calcium oxide to be dipoles.

Question 19

Both parts of this question were well answered.

(a) Common errors in this part resulted from carelessly drawn diagrams in which either hydrogen atoms and bonds were omitted or too many bonds were drawn around the carbon atom. Many students gave extra information which was not required.

(b) Common errors were the inclusion of:

(i) catalysts such as *Ni* and *Pt*

(ii) UV light

(iii) by-products such as HB_r and H_2

(iv) adding 2 bromine atoms to the same carbon atom

(v) incorrectly writing the formula for bromine.

Question 20

(a) This part was generally very well answered by the majority of candidates.

(b) This was also well answered, although some students had difficulty in correctly completing the calculation as they failed to determine the equilibrium concentrations.

Question 21

(a) Students had a good understanding of the polar nature of water and were able to describe why ethene is not soluble in water.

(b) (i) This part was poorly answered, as many students wrote about the *type of reaction* (addition versus substitution) rather than the bonds (single carbon-carbon versus double carbon-carbon bonds) which cause the reactions. Candidates failed to compare *ethene* with *ethane* or were not specific about the bonds to which they were referring.

(ii) This was poorly answered by a number of students who had trouble in identifying the halogen group or considered H_2 to be a product of the reaction.

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Question 22

(a) Many students were able to select correctly the forward reaction as the one that predominated until the system reached equilibrium. The explanation for the cause of their selection was not as good.

Many:

- did not appreciate the fact that the original mixture was not in equilibrium and used Le Ch>telier's principle
- could not realise that the equilibrium constant was greater than 1
- discussed the concentration of the element carbon.

(b) In general the answers here were satisfactory.

Question 23

(a) This part was, on the whole, very well answered. Errors arose due to:

- lack of knowledge of the valency of barium or hydroxide ions
- inability to use the periodic table correctly, i.e. the atomic mass of bromine was used instead of barium
- transcription errors in which 137 was used as the atomic mass for barium instead of 137.3.

(b) (i) This was reasonably well done; some common errors, however, included:

- halving the concentration of barium hydroxide rather than doubling it
- not converting the volume of the solution from mL to litres
- multiplying the number of moles of barium hydroxide by the volume, rather than dividing, when calculating the concentration
- being unable to use the exponential function on their calculators.

(ii) This part was reasonably well answered, but some students, in calculating the pH, failed to calculate the hydrogen ion concentration and simply used the concentration of the hydroxide ion.

Question 24

(a) Here students displayed good knowledge of esters, their naming and structure, and the question was well answered.

(b) Most students knew how ethyl ethanoate can be made from ethanol and ethanoic acid, but many failed to show the first step involving the conversion of ethanol to ethanoic acid. The majority were unable to write a balanced equation for the oxidation of ethanol to ethanoic acid. The most common error in the formation of the ester was the omission of water as a product.

Question 25

(a) Answers here were reasonably good, although there were some candidates who failed to write a balanced equation, while others were unable to give the formula for the sulfate ion.

(b) This question was, on the whole, poorly answered. Some common errors included:

- concentrating on the ethanoate ion and ignoring the sulfate ion
- discussing the Lowry-Bronsted theory without explaining why sodium ethanoate is basic
- being unable to write an ionic equation
- failing to explain why sodium sulfate is neutral
- answering in general terms and not correctly identifying the acid/base species
- using word equations rather than ionic equations as specified in the question.

PART C

Question 26

(a) This part was very poorly answered, as few candidates appeared to be prepared for primary standards from the beginning. Some did not seem to understand the meaning of *anhydrous* and why it was important that the primary standard should be dry.

(b) A number of students were unable both to draw and to name the appropriate glassware in which the sodium carbonate solution was prepared. The standard of drawing was very poor in many cases.

(c) Writing a balanced equation to describe the reaction between sodium carbonate and nitric acid was well done by many students; common errors, however, included:

- giving *carbonic acid* as a product rather than *carbon dioxide* and *water*
- failing to balance the equation
- giving the incorrect formula for sodium carbonate and/or nitric acid.

(d) A significant number of students experienced difficulties in calculating the concentration of the nitric acid solution; common errors included:

- averaging the volumes of the four titres
- failing to convert the volumes to litres
- rounding off during the calculation
- using the formula $M_1V_1 = M_2V_2$
- disregarding the units.

Question 27

(a) This part was done badly since candidates:

- had difficulty in interpreting the question
- failed to realise that the final solution was basic
- were unable to deduce that the nitrite ion formed from a weak acid
- did not write an acid-base reaction between nitrite ion and water.

(b) Students were able to determine the pH of the solution from the table. Although calculation was well handled, common errors included:

- rounding off inaccurately
- unsuccessfully converting a correct pH value to the correct hydroxide ion concentration.

(c) Most students could select the correct indicator, but many could not explain their choice. Students from some centres were unable to interpret the graph correctly, while terms such as *end point*, *equivalence point*, *neutralisation* and *equilibrium* were commonly used incorrectly.

(d) Few were able to explain why a minimum volume of an indicator solution is used in titration reactions. Responses to this question indicated that, where students are using indicators in experiments, they do so without any great understanding of the nature of such compounds.

Question 28

It was clear that many students had a very poor understanding of equilibrium as they were unable to cope with the unfamiliar nature of the reaction.

(a) (i) This question was generally well answered, although the quality of student expression was often very poor.

(ii) This was, on the whole, very well answered, with the most common error resulting from answers which included the presence of both yellow and red colours. Students recognised the fact that all ions were present in the equilibrium mixture, but did not understand the significance of the small *K* value when predicting the colour observed.

(b) Very few students correctly understood the mechanism by which the acidity changed. Many believed that the dry ice reacted directly with the hydroxide ion to lower the pH. Some students clearly confused *dry ice* with *ice*, even though the formula was stated; others felt that the pH changed as a result of the sudden temperature change.

(c) Many were confused by this question and tried to explain the *frothing blood-like* nature of the mixture, instead of explaining the equilibrium shift that occurred to produce the colour change. A number of students tried to explain the equilibrium shift in terms of a response to the sudden temperature change, even though no indication of the enthalpy change involved was given.

Question 29

The majority of candidates answered all parts of the question and appeared to be accustomed to using all the terminology and concepts required. Clarity of expression, precise use of language and a clear understanding of the concepts were, however, not always evident. Students must be encouraged to give clear and concise answers that do not contain contradictions.

Candidates need to be aware of distinctions between key terms in the question such as *name*, *describe* and *explain* and must avoid the temptation to restate the question as their answer.

In cases where over-writing or crossing out occurs, the candidate's intention should be made clear.

(a) This question was generally handled well as the information was supplied in the question. Many students, however, are still failing to include states in equations, while a number included incorrect states, even when the correct information was supplied. Reactants and products must be written in the conventional equation order.

(b) Since an increasing proportion of candidates are familiar with the concept of co-ordinate covalent bonds and their mode of formation, the majority of candidates were familiar with the concept of *electron dot* diagrams. Most incorrect answers occurred when candidates failed to indicate the presence of a charge on the ion or to indicate that the charge was delocalised.

(c) The majority of candidates were familiar with the correct use of sub-shell notation to indicate electron configuration. Incorrect responses generally provided the configuration for chlorine rather than for the chloride ion.

(d) Students generally appeared to know the name for co-ordinate covalent bonds and responses ranged across the full spectrum of possible types of bonds and intermolecular forces.

(e) Few candidates could adequately answer the question. A number failed to provide an explanation that appropriately linked the nature of the bonding with the properties of a solid. Many simply restated the question or gave *strong ionic bonds* as their response.

Students need to use precise language and not refer to ionic solids as *consisting of molecules* or *possessing intermolecular forces*. A clear understanding of forces of attraction between ions needs to be accurately communicated in students' answers.

Question 30

The majority of students attempted this question which was, in most cases, well answered. There were, however, a number who showed virtually no understanding of the topic.

Many had difficulty in confining their answers to the space available, while the standard of written expression was poor, with many students confusing concepts and their uses. Abbreviations were frequently used and these often led to ambiguities. A number of responses were written in pencil or were almost illegible, and many candidates attempted to use rote-learned phrases, e.g. *sea of electrons*, without understanding their meaning.

(a) The majority of candidates recognised the concept of delocalised electrons in metals. Common errors involved the use of atoms, nuclei or protons instead of positive ions or the use of mobile ions to explain conductivity.

(b) Many students failed to link the hardness of a diamond to the rigidity and strength of its structure; a large number of responses could have applied equally to diamond or to graphite. Use of intermolecular forces in diamond or incorrect descriptions of bonding occurred in a number of answers.

(c) This was correctly answered by the majority of candidates. Some obviously confused hydrogen bonding with the hydrogen-oxygen covalent bond, while others were not aware of the formula, structure and properties of hydrogen sulfide.

(d) On the whole this was well answered in terms of *polarity* but few students attempted to explain *polarity* in terms of bonding.

(e) This was correctly answered by half the candidature. Some, however, suggested that helium was a covalent molecular substance or that helium was diatomic and non-polar. Others stated that there were no forces between the helium atoms.

Question 31

(a) The majority of students were able to determine the formula as being C_6H_{12}.

(b) (i) Most candidates recognised compound *A* as being an alkene, but failed to link the formula with the product *E*, consequently they drew the structural formula for
1-hexene or cyclohexane.

(ii) Although addition reactions were known, the most common error was to add chlorine rather than hydrogen chloride.

(iii) The oxidation of alkenes was not well understood.

(c) 2,3-dimethyl-2,3 butandiol was named quite well. The prefix *di* was often omitted or was placed in the incorrect position when referring to the butandiol, e.g. dibutanol.

SECTION II : ELECTIVES

PART B

Number of Candidates choosing each Elective

	Elective Name	**Number of Candidates**	**% of Candidates**
Question 32	Chemical Energy	5593	54.42
Question 33	Oxidation and Reduction	3599	35.02
Question 34	Biological Chemistry	761	7.40
Question 35	Chemistry and Environment	273	2.66

Question 32 : Chemical Energy

(a) (i) Most students could describe from the table the relationship between the volume of gas and the pressure changes, with many giving their answers as a mathematical relationship.

(ii) This was well answered, although some students were not familiar with the terms *relationship* and *proportional.*

(iii) The majority answered this well, with a variety of axes being used. Many plotted the points given in the table rather than sketching a graph as the question required. A number drew a straight line of best fit through the points, even though these points gave an obvious curve.

(iv) Although many students are still not giving units in their answers, responses to this part were generally good.

(v) Deviations from ideal gas behaviour were often not explained in terms of molecular volumes and interactions. A number of students thought that the ideal gas relationship held until a change of state occurred.

(vi) Although nearly half of the candidature did not convert the volume to litres for use in $PV = nRT$, the rest answered this well. Likewise a significant number did not convert temperature into Kelvin units.

(vii) A number of students did not realise that there would be no difference in the results when an equal number of moles of hydrogen gas was substituted for carbon dioxide.

Many stated in their answers: *the volume would be less because the hydrogen molecules are smaller.*

(b) (i) This part was answered correctly by most students, although many gave a *general* rather than a *major* use of a fuel, e.g. in cars or for cooking.

(ii) This was well answered, the most common errors resulting from:

- incorrectly balanced equations
- failure to include the values for breaking the 0=0 bond in the calculations.

Responses showed that students did not differentiate between *heat of combustion* (a positive value) and *enthalpy of combustion* (a negative value).

(c) (i) Most candidates made a good attempt at this question and were able to give correctly the heat liberated when 4.0g of solid sodium hydroxide was dissolved. Some common errors included:

- inability to calculate the enthalpy released per mole
- selection of the wrong mass to use in calculations
- giving the incorrect sign for enthalpy change
- converting the temperature to degrees Kelvin.

(ii) Answers here were poor, with many students apparently being completely confused. The majority were unable to apply Hess's Law and found it difficult to calculate the correct mole ratio.

(iii) 1. Far too many students listed the equipment they would use for a heat of combustion or titration experiment and their answers indicated that:
- either they had not done the mandatory experiment, or
- they had not understood the practical work.

2. Although this was generally well answered, a significant number of students gave a 1:2 ratio of volume. Many failed to state a volume as required by the question.

3. This was well answered but *human mistakes* were often given as sources of errors.

(d) This part was handled reasonably well; some common errors included:
- not correctly balancing the equation
- incorrectly applying the formula
- being unable to follow through to the correct value for 100g of ethanol, in spite of having correctly calculated the enthalpy change.

(e) On the whole, this was well answered, although some answers were too vague, saying, for example, *hydrogen is non-polluting, volatile, flammable.* Some made incorrect statements concerning activation energy and ignition temperatures. The majority were able to balance the equation correctly in part (iii), but others failed to give the correct sign for the energy term.

Question 33 : Oxidation and Reduction

(a) (i) This part was reasonably well answered since most students were able to identify Equation 1 as oxidation. Some, however, did not appear to be very familiar with this type of reaction.

(ii) Answers here were very good; a common error was to show nine electrons in the half-equation. This was the result of not balancing the half-equation in relation to the chromium ions or through neglecting to double the charge on the chromium ion.

(iii) Most candidates successfully applied the appropriate multipliers to eliminate the electrons from their combined equation.

(iv) Few candidates scored full marks here; some seemed to be unprepared to handle this type of mole calculation. Errors included:

- ignoring the mole ratios
- incorrect calculation of the formula mass of ethanol
- incorrect application of the molar mass of ethanol
- some students found difficulty in expressing themselves clearly in making the comparison. Their answers often indicated that they perceived a difference between *legally drunk* and *illegally drunk*.

(b) (i) Although this was generally well answered, some candidates selected very reactive metals, e.g. potassium or sodium, which are not really *suitable* for this type of displacement reaction.

(ii) While most students correctly selected the most reactive metal, it was disappointing that a significant number wrote half-equations, couples or metal ions instead of the name or symbol of metal. Many had difficulty in justifying their choices. Common errors were:

- lack of understanding of the difference between an oxidation and a reduction potential
- responses referred to *higher* or *lower* potentials without specifying whether such potentials were oxidation or reduction
- incorrect use of symbols - either element or ion - which caused contradictions in the explanations given.

(ii) Answers to this part were good.

(c) Definitions, including the use of examples, of *oxidant* and *oxidised* were generally of high standard, although some candidates had some difficulty with the tense of the word *oxidised*. The better answers were expressed in terms of gain or loss of electrons. Poorer responses were expressed in vague terms, e.g. *oxidant means oxidises, oxidised means combination with oxygen*.

Some had difficulty in giving a concise definition for the terms, while a number presented long, convoluted answers in which they often found it easy to contradict themselves.

(d) (i) Some students did not recognise the fact that the question was asking about the properties of the oxide layers and their answers indicated that a number considered the heat to be trapped under the magnesium oxide layer.

(ii) 1. The majority considered the problem to be a structural one and stated that the oxide layer caused rust or was itself rust.

2. Most candidates answered this well.

(e) This question was answered reasonably well. The majority realised that, for a spontaneous reaction at standard conditions, the voltage must be positive. Common errors included:

- selection of incorrect values from the E^o table (1.40 instead of 1.36 for chlorine half-equation)
- failing to do the sum process
- not stating the answer in each case.

(f) Electrolysis was not well understood. About 20% of the candidature drew two half cells linked by a slat bridge. Battery symbols were inaccurate or negated by other information, while voltmeters/ammeters were shown in many cases.

(i) The majority of candidates did not place the whole spoon in the solution. Many thought that the anode was nickel.

(ii) A number of candidates used the SO_4^{2-} half-equation, unaware of the water as the species to be oxidised. Many wrote equations for the oxidation of nickel or platinum, indicating poor understanding of the concept of an inert electrode.

(iii) The majority of students recognised the fact that the reaction was the reduction of nickel.

(iv) Good students realised that an oxidation and reduction potential must be added together and a positive voltage required in order to obtain the minimum voltage needed to plate the spoon.

Question 34 : Biological Chemistry

(a) (i) 1. This was well answered.

2. This was also well answered.

(ii) and (iii) Candidates answered both these parts well.

(iv) Most students realised that polarity was involved here, but could not relate this fact to the interaction between the hydroxy functional group and water.

(v) Almost half the candidature wrote an equation which included water and used structural formulae. Common errors included:

- leaving off a bond
- drawing a bond to the hydrogen in an OH or CH_2OH group
- having an unbalanced equation omitting water.

(vi) Only a small number of candidates realised that all three compounds ! I, II and III ! were reducing sugars.

(vii) The majority of candidates named a suitable reagent for determining whether a carbohydrate is a reducing sugar. Common errors included:
- leaving out an important step, e.g. warming with Benedict's solution
- failing to describe the expected colour change.

(viii) Answers here were good.

(b) (i) Even though a diagram of an amino acid was given on the examination paper, only half of the candidates could draw the zwitterionic structure of threonine.

(ii) Answers here were poor, since most candidates gave an equation and reasons for the zwitterionic structure of amino acids without providing evidence although the question required it.

(iii) Answers here were also poor. Although most candidates could name the carboxyl group, many could not name the amine/amino group correctly. Others gave the formulae for the functional groups instead of naming them.

(iv) Half of the candidature could draw the dipeptide structure but many were unable to produce an error-free diagram.

(c) Most candidates successfully explained *denaturation of a protein*. The majority of these gave examples which involved egg without specifying the white of the egg and rarely named the protein involved as *albumin.*

(d) (i) Most candidates correctly named *protein*, but many incorrectly stated *amino acids.*

(ii) Although many students gave a specific enzyme example (often extracellular) instead of two general reasons for enzyme usefulness in cells, this part was well answered.

(iii) The majority of students did not draw a straight line through the origin. Many drew curves or the graph for rate and substrate concentration, instead of a graph to show the relationship between the initial rate of an enzyme reaction and the enzyme concentration.

(iv) Answers here indicated a good knowledge of practical work. Most students described a protein test such as Biuret to distinguish sucrase from sucrose. Most of those who used a reducing sugar test correctly described acid hydrolysis before testing, but did not point out that the acid should be neutralised before testing with the alkaline Benedict solution.

(e) (i) Answers here were good. Common errors, however, included:
- failing to balance the oxygen in the equation
- giving the equation for respiration instead of that for photosynthesis.

(ii) This was well answered, with most students being able to calculate the mass of glucose formed from the photosynthesis of 1500L of carbon dioxide at 27^{o}C.

(iii) Here most students correctly named *glycogen* although some gave *ATP*.

(iv) Many failed to gain a mark when they wrote a single word, *energy*, as an answer to a question which began with the word *why*.

(v) Only a small number of students were able to indicate a connection between growth and ATP production in explaining the differences between the aerobic and anaerobic growth of yeast.

Question 35 : Chemistry and the Environment

(a) (i) Most students, realising the effects that animal activity could have on faecal bacteria and dissolved oxygen, named River A, basing their decision on the data given.

(ii) 1. The majority of students suggested a possible reason for the differences in dissolved oxygen, many connecting a high level of bacteria with a low level of dissolved oxygen.

2. Few could suggest a reason such as the fact that decay of plant matter lowers pH or that flowing over carbonate rocks raises pH

(iii) Although the Syllabus has examination of water samples for micro-organisms as a mandatory experience, few students appeared to have prepared a culture and incubated it. Many had obviously done B.O.Ds without realising that B.O.D. is affected by large organism respiration and photosynthesis as well as by organic matter levels from sewerage, industrial wastes and decay.

(iv) Most candidates could name a reagent that could be used to neutralise a sample of river water and justify their choice.

(b) (i) The majority of students did not appear to have studied temporary hardness due to dissolved hydrogen carbonate ions and thus disregarded the stimulus material. The majority gave an answer more suitable to part (ii), writing about the amount of soap required to lather water.

(ii) This was fairly well answered, although a small number of students, in accounting for the cause of hardness in water, could not give the correct charge for a calcium or magnesium ion, while others implied that hardness was caused by calcium or magnesium as the element rather than in ionic form.

(iii) Answers here were good.

(c) (i) This part was not well answered. Common errors included:
- dividing molarity by volume instead of multiplying
- using the incorrect formula for barium chloride
- incorrectly calculating the mass of the sulfate ions.

(ii) Answers here were good, since most students knew that combustion of fossil fuels releases sulfur dioxide which, after oxidation to sulfur trioxide, reacts with water to form sulfate ions.

(d) (i) Few students realised that a beta particle is an electron, consequently they were unable to write a balanced equation to describe the nuclear decay of strontium-90.

(ii) Nearly half of the candidates recognised that calcium and strontium-90 are in the same group and have the same outer electron configuration.

(iii) and (iv) These two parts were well answered.

(v) On the whole answers here were good, some, however, were very general and lacked specific examples such as SYNROC or glass techniques.

(e) (i) Although this was fairly well answered, many candidates thought that oxides of nitrogen from power stations destroy stratospheric ozone and/or contribute to the greenhouse effect. They gave this as an important reason for controlling the emission of waste gases from power stations.

(ii) Only a small number of candidates appeared to know any gas test for sulfur dioxide.

(iii) Nearly half of the candidature answered this correctly. A number correctly calculated the percentages but allocated them to the wrong gas.

(iv) 1. Although a number of candidates confused *ozone depletion* with the *greenhouse effect*, this was, on the whole, answered satisfactorily.

2. Answers here were often more general than scientific.

(f) (i) and (ii) Both of these parts were badly answered.

(iii) Most candidates gave a suitable formula for gas *B* but some added a charge or incorrectly named a correct formula, thus losing marks.