

Moderators' Report/  
Principal Moderator Feedback

Summer 2016

Pearson Edexcel GCE  
in Chemistry (6CH01)  
Core Principles of Chemistry

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## Report on 6CH01, June 2016

Many candidates were well prepared for this paper, and the general standard reflected the fact that nearly all candidates were in their second year of study. The questions which were least well done were those where candidates had to structure longer responses, such as explaining trends in ionization energies, or explaining what happens to carbon-carbon double bonds in addition reactions. As usual there were many errors due to candidates not reading the question with enough care, and giving answers without required units or state symbols, or with an incorrect number of significant figures or decimal places.

### Question 18

Some candidates gave the formulae of negative ions in (a)(i) and lost both marks. Despite the question asking for ions containing only the  $^{16}\text{O}$  isotope there were answers involving  $^{17}\text{O}$ ,  $^{18}\text{O}$  and elements labelled as O atoms but with a variety of atomic numbers. The most common correct answers were oxygen atoms or  $\text{O}_2$  molecules with either one or two positive charges.

Most candidates knew that ions were separated by a magnetic field. If two alternative answers were given eg the magnetic field and the detector the mark was not allowed.

In (a)(iii) the answer depended on the choice of ions. Some candidates did not understand the term "deflection" and drew a diagram with a label stating that heavier ions were deflected less than lighter ions, which is true, but drawing the path of the heavier ion with more deflection. Answers showing the path of the ions as a straight line lost one of the marks. If negative ions were given in (a)(i) marks were allowed in (a)(iii) for the principle that deflection was greater for lighter ions and more highly charged ions.

The method of calculation in (b) was well known. However the final answer was often calculated incorrectly, and the requirement for three decimal places often resulted in an answer to three significant figures.

Answers to (c) showed that candidates did not appreciate the significance of a standard. Many answers said that one sixteenth of the mass of an oxygen atom would not be a whole number making it an inconvenient standard. Others thought that the problem was that oxygen was a diatomic gas or that it did not have a mass of 12. Many different answers were allowed; the one which was given correctly most often was that a specified isotope would have to be used. Saying that a mixture of oxygen isotopes is present in air just repeated information given in the question, and was not given credit.

Most candidates realised that there would not be a difference in electron affinities of  $^{16}\text{O}$  and  $^{18}\text{O}$ . For credit, answers had to say that the isotopes had the same number of protons, or that only the number of neutrons varies. Answers which only referred to the number of electrons present were not given the mark.

## Question 19

The equation in (a) for the first ionization of magnesium was well known; the most common error was to add an electron to the atom (but still produce a positively charged ion!) Examiners look very carefully at the state symbols but occasionally the handwritten symbols (s) and (g) are written so badly that they cannot be distinguished and the candidate loses a mark. The electron configuration in (b) was another straightforward question. A few answers gave the configuration for an element with 27 electrons due to confusing the mass number of aluminium with its atomic number.

The questions on trends in first ionization energies were very discriminating. Candidates need practice in constructing answers like this, and their inability to present a logical explanation cost many marks.

Many candidates seem to think that the most important factor to consider is the number of electrons in each orbital. Many answers said that magnesium was relatively difficult to ionize because there were two electrons in its outermost (3s) orbital which made it stable, and then went on to say that sulfur was relatively easy to ionize because there were two electrons in one of its outermost (3p) orbitals which repelled each other. Many other responses mentioned the distance from the nucleus as being a factor, even though this is difficult to compare for an s and p orbitals.

There is an increase in proton number going from magnesium to aluminium, and also going from aluminium to silicon; for full marks in (c)(i) candidates had to explain that the changes in ionization energy were due to the relative importance of an increase in nuclear charge and the amount of shielding of electrons or their different energy levels. The point that silicon has one more proton than aluminium but the outer electrons are equally shielded (or in the same sub-shell) was often missed. In (c)(ii) many graphs showed that sulfur does not follow the trend of increasing ionization energy, but the explanation then discussed silicon. This appeared to be carelessness as the electron configuration of sulfur was attributed to silicon. However the repulsion of the two electrons sharing a 3p orbital was relevant here and the mark for (c)(ii) was often higher than for (c)(i).

The dot and cross diagram in (d) for silicon tetrachloride was generally well done, though a surprising number of answers only showed the shared electrons of chlorine and left out the other six electrons in the outer shell of each Cl atom.

There were some good explanations in (e)(i) of how polarization arises. In attempts to explain the meaning of the term polarization, some answers talked about the highly charged magnesium ion attracting the iodide ion. This is a description of an ionic bond but polarization of the ion involves the distortion of its spherical shape. A few candidates described polarization in a covalent bond despite the question clearly referring to ions.

Answers to (e)(ii) frequently said that theoretical data should be compared with experimental data to show if there is polarization. However they did not say which piece of data should be compared. Some answers said that experimental

values for lattice energy should be compared with the lattice energy value obtained from the Born Haber cycle. These candidates did not realise that the Born Haber cycle is based on experimental data.

#### Question 20

A few candidates in (a)(i) thought that fractional distillation depends on melting temperature. Others put both melting temperature **and** boiling temperature and were not awarded the mark. Candidates need to know that they should not put a list of answers when only one is correct.

Many candidates knew that cracking an alkane means breaking the carbon chain to produce a smaller molecule or an alkene and hydrogen. However many candidates incorrectly believed that reforming was the reverse of cracking. Their answers were descriptions of polymerization.

The calculation in (a)(iii) was often well done. The most common reason for loss of marks was to leave out the sign or to give the unit incorrectly.

There were several possible equations in (a)(iv) for cracking butane, but it had to show products other than formation of propene and methane. Some candidates misread the question here. It was disappointing to see the products given as  $2C_2H_5$ .

Most candidates scored the first mark in 20(b)(i) for calculation of the heat energy transferred. However a high number of candidates thought this was the final answer since the mass of pentane burnt was 1.00 g. They did not calculate the enthalpy change per mole. Other marks were lost because a sign and units were missing from the final answer.

The most likely reason for heat loss in the experiment is incomplete combustion of pentane. The answer "incomplete reaction" has a different meaning and was not accepted. Evaporation of pentane might also occur, but evaporation of water in the calorimeter was not allowed. A mark was allowed for saying that the heat capacity of the calorimeter was not included, but not for saying that the specific heat capacity of water was incorrect. It was disappointing to see answers blaming measuring errors, non-standard conditions and impure pentane for the results of the experiment.

Pentane is highly flammable. However many candidates were led on by their answer about incomplete combustion in (b)(iii) to say that the hazard in this experiment would be carbon monoxide production. This did not show much experimental awareness as only 1.00 g pentane was used. Other candidates said that flammable compounds should not be used in schools, again forgetting any experimental work they had done with organic chemicals.

The equation in (c)(ii) was usually answered correctly, except by those who did not read the question carefully and gave an equation for propane. In past papers there have often been questions asking candidates to use bond enthalpies to measure the enthalpy of a reaction. In (c)(ii) there was no calculation of an enthalpy change, just a requirement to identify the type and

number of bonds broken and formed during combustion of a mole of pentane and many errors were made. The number of C-C bonds in pentane was said to be five; the O=O bonds in oxygen were omitted or said to be single bonds; carbon dioxide was described as having single C-O bonds. Sometimes a total number of bonds was given without identifying what they were. In (c)(iii) the reason for the enthalpy change of combustion being exothermic was often answered in terms of the total number of bonds in reactants and products, and bond making was regularly described as a process which needs energy.

#### Question 21

Answers to (a)(i) often referred to "lone electrons" or even lone pairs in attempts to describe a free radical. Credit was given to answers referring to either atoms or molecules, though many used the term "species" which covers both cases. Answers saying that free radicals had unpaired electrons (i.e more than one) were not given the mark.

The arrows showing free radical formation in (a)(ii) should have been curly half-arrows. Full arrows did not get the mark and the diagram had to show the arrows going from the bond to the Cl or close to it, and not up in the air to no particular destination.

Most candidates realised that ethane and a chlorine free radical react in a propagation step and only a few gave incorrect products. The equation for a termination step was also well answered.

The diagrams in (b)(i) of sigma and pi bonds were very variable. Some showed the double bond as two lines with one line labelled sigma and the other pi and did not score. Some showed two p orbitals with no overlap or any indication of linkage and did not get the mark for the pi bond. Diagrams showing overlapping p orbitals or an electron cloud above and below the sigma bond earned the mark. The sigma bond had to be shown between the two carbon atoms, and an ellipse stretching from regions beyond each atom was not allowed.

The description and explanation in (b)(ii) of what happens to these bonds during addition was also very variable in standard. Most candidates got one mark for stating that the sigma bond remains, but did not give the explanation that this is because good orbital overlap makes them strong. Many answers stated that the pi bonds break but did not explain that this occurs because they are weaker, or go on to say why they are weaker.

The colour change in (b)(iii) was usually correct, but the product was often shown with only one -OH group. Bonds from C to the H atom in OH were not allowed. The test and colour change in (b)(iv) were also well known. If candidates selected bromine as the test reagent instead of bromine water they were not allowed orange or yellow as the starting colour.

Candidates were very familiar with the mechanism of the reaction of ethane with hydrogen bromide. The most common errors were the direction of the curly arrow from the double bond and the formation of Br with a  $\delta^-$  charge instead of a full negative charge after the first electron movements.

Skeletal formulae were required for the organic compounds in 21(c); some answers drew pent-1-ene instead of but-1-ene but many answered correctly and named a suitable metal catalyst.

### Summary

The knowledge of organic chemistry and ability to write a mechanism were good. However when it came to explaining why the mechanism takes place as it does, by considering the structure of the double bond, then answers were less well done.

The calculations were well done, though many candidates have little feel for the appropriate use of significant figures.

The weakest area was the ability to structure an explanation. Candidates would benefit from more practice in writing explanations one point at a time. They should try to avoid simply putting down any facts they know, even if irrelevant, and to avoid repetition.

