

Examiners' Report

January 2017

GCE Chemistry (WCH05) Paper 01
General Principles of Chemistry II
– Transition Metals and Organic
Nitrogen Chemistry (including
synoptic assessment)

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk for our BTEC qualifications.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

If you have any subject specific questions about this specification that require the help of a subject specialist, you can speak directly to the subject team at Pearson.

Their contact details can be found on this link: www.edexcel.com/teachingservices.

You can also use our online Ask the Expert service at www.edexcel.com/ask. You will need an Edexcel username and password to access this service.

Pearson: helping people progress, everywhere

Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

February 2017

Publications Code xxxxxxxx

All the material in this publication is copyright

© Pearson Education Ltd 2017

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

<http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx>

General

Some candidates were very well-prepared for this examination and scored high marks. Many candidates were able to demonstrate that they had a sound knowledge of the topics in the specification and could apply this to the questions with just a few errors or omissions. Some candidates would benefit from much more preparation to ensure that they know the basic facts, can express their ideas clearly and carry out calculations, showing their working.

Section A

The mean mark for the multiple choice questions was 12.37, which is slightly lower than for some past papers. The highest scoring questions were 1 and 5, with over 80% of candidates achieving these marks. The most challenging question was 20, with 26% of candidates achieving this mark.

Section B

Question 21

The majority of candidates are familiar with the mechanism for the nitration of benzene. Some candidates were unable to write a balanced equation for the formation of the NO_2^+ electrophile and others were unsure about what the electrophile was so neutral species and negative ions were seen. Other common errors included poorly drawn curly arrows, the horseshoe in the intermediate not facing the tetrahedral carbon atom, the positive charge not within the horseshoe, adding an additional charge to the NO_2 group or the hydrogen atom in the intermediate and drawing a curly arrow starting from the hydrogen atom instead of the C-H bond.

Many candidates were able to identify the reagents needed in Step 2 of the reaction scheme. However, many candidates did not realise that the temperature in Step 3 should not be higher than 10°C otherwise the benzene diazonium chloride will decompose. Some candidates thought that the sodium nitrite or phenylamine would decompose above this temperature and a few just referred to the compound decomposing, without stating which compound. A few candidates thought that there would be multiple substitutions at a higher temperature.

Many candidates could draw the structure of benzene diazonium chloride but a minority included a bond between a nitrogen atom and the chloride ion. There were many correct answers for part (v), although some candidates were careless in showing the H of the OH group attached to the benzene ring. The reagent and conditions for the preparation of methylbenzene from benzene were usually well-known, although a small number referred imprecisely to 'chloroalkane' or 'haloalkane'.

There were some excellent answers to part (c) that scored full marks. Some candidates lost marks by omitting small details but a number were unable to start the synthesis. Common errors included: just stating potassium dichromate(VI) for the oxidising agent and omitting the acid, omitting the dry ether from lithium tetrahydridoaluminate(III), not showing how to form phenylmethanol from benzaldehyde, using phenol instead of phenylmethanol as the alcohol and omitting the addition of a strong acid during the esterification when using benzoic acid and phenylmethanol. Some candidates included an extra step in which they converted benzoic acid to benzoyl chloride and this was acceptable.

Question 22

Many candidates scored 1 mark for one correct electronic configuration in (a)(i). A significant number of candidates showed electrons lost from the 3d orbitals in the two ions and left one or two electrons in the 4s orbital. Many candidates knew that transition element forms one or more stable ions with an incomplete d sub-shell but only a small minority realised that in a d-block element, it is the last electron to be added that enters a d orbital. There were many answers that incorrectly stated the outer electron is in the d sub-shell.

Part (a)(iii) was poorly answered. Many candidates did not relate their answers to the stability of a half-full d sub-shell of electrons. Some candidates wrote about partially filled d orbitals when they clearly meant half filled. There was also confusion between orbitals and sub-shells as some candidates wrote about the stability of a half-full d orbital. Candidates should be encouraged to refer to the d sub-shell to avoid the problem of just mentioning one d orbital.

Many candidates did realise that the ions have different colours in aqueous solution as the ligands will cause different splitting of the d orbitals so the electrons will absorb different frequencies of light when they are excited from a lower energy d orbital to a higher energy d orbital. Some candidates just mentioned absorbing energy, colour or light and a few candidates thought there were different ligands present in the complex ions. There were some answers which showed the candidates were confused with emission spectra.

Some candidates gave clear explanations of how they deduced the final oxidation number of manganese. Others gave a jumble of numbers and finally wrote down the correct answer or a different number. Candidates were only awarded a mark if they gave some correct explanation based on the data given in the question. Some candidates did not look carefully at the formula for arsenic(III) oxide and they thought that there was just one arsenic atom in each formula and five of these lost 10 electrons. A few candidates deduced the two half-equations and the overall equation between potassium manganate(VII) and arsenic(III) oxide and they were awarded full marks.

The majority of candidates could give the meaning of bidentate ligand although some referred to two ligands or implied that one ligand formed a double bond to the metal ion and others just stated that the ligand has two lone pairs of electrons but did not mention using them to form bonds to the metal ion. However, only a small minority were able to deduce the structures of the two bidentate ligands. Many candidates scored 1 mark for the structure of 1,2-diaminocyclohexane but the majority of candidates did not put the negative charges on the ethanedioate ion. The oxidation number of platinum was often incorrect. Some candidates ignored the information in the first line of (c) that told them that the platinum is an ion and they wrote 0 as the oxidation number.

Question 23

Many candidates could suggest suitable reagents for Steps 2 and 3. However, the majority of candidates seemed unfamiliar with the reaction between an amine and chloroethane so they were unable to draw a correct organic product in (a)(iii). Many incorrect structures showing a chlorine atom or an ester group were seen.

The zwitterion of tyrosine was often correct, although some candidates omitted the OH on the benzene ring or changed it into an ion and others omitted to protonate the NH₂ group. The two optical isomers were often correct, although candidates should be advised to just draw them as mirror images of each other and not to swap another two groups around and give the original molecule again. Many candidates were able to draw the polyamide formed from tyrosine, although some did not display the amide linkage, some added an extra oxygen atom in the linkage and others

drew more than two repeat units. Candidates found it much more difficult to draw the polyester formed from serine and many drew another polyamide.

Part (c) was difficult and was intended to test candidates' ability to apply their knowledge to a new reaction. It was pleasing that many candidates were able to draw the structures of the correct aldehyde and amino acid. Many candidates thought that it was not possible to distinguish between tyrosine and serine by their infrared absorbance in the 4000 to 2000 cm^{-1} range as they just stated that the amino acids have the same functional groups. However, they should have considered the absorbance from the C-H bonds in the arene group in tyrosine that is not present in serine.

Candidates found part (e) more challenging than expected. Many candidates were unable to work out the correct splitting patterns and some quoted the chemical shift for the OH proton as that of an alcohol instead of a carboxylic acid.

Question 24

Many candidates could draw an acceptable dot and cross diagram for a sulfate(VI) ion, although some candidates showed three or four double bonds, some included a lone pair of electrons on the sulfur atom and others omitted the additional two electrons from the $2-$ charge. A few candidates just drew bonds and did not include the electrons. The shape of the ion was usually correct.

Many candidates could complete the calculation in (a)(iii) correctly. Common errors included stopping after just working out the number of moles of lead(II) sulfate(VI) added and rounding numbers too early in the calculation, e.g. 9.55395×10^{-3} rounded to 1×10^{-2} .

Candidates were unable to write the balanced equations in (b). Some candidates were unable to write the correct formulae for sodium disulfate(VI) and sodium sulfate(VI), even though the formulae of the ions were given in the information at the start of the question. The formula for ammonium dichromate(VI) was often incorrect and $(\text{NH}_3)_2\text{Cr}_2\text{O}_7$ was a common error. Some candidates gave the correct formulae but omitted to balance the equation.

Many candidates were able to select the correct value for E^\ominus to complete the table but they did not give the correct half-equation. A common error was to omit the electrons or include an incorrect number of electrons. Many candidates were able to deduce the correct species of the strongest oxidising agent, although some gave the half-equation and did not state which species in the equation is the oxidising agent. Many candidates were unable to select the two half-equations that involved the manganate(VI) ion and only a small number were able to add them correctly so that the electrons cancelled. The E^\ominus_{cell} value was sometimes correct but many candidates gave the wrong sign, added the values for the half-cells instead of subtracting them or used the wrong value for the hydrogen peroxide half-cell.

A minority of candidates drew clear diagrams of the apparatus used to determine the standard electrode potential of the dichromate(VI)/chromium(III) electrode. The most common omission was not adding acid to the dichromate(VI)/chromium(III) half-cell. Other common errors included: adding a cell to the circuit, not having a complete circuit as there was no solution in at least one beaker or the end(s) of the salt bridge were not in the solution(s), using a chromium electrode instead of platinum, putting chromium(III) in one beaker and dichromate(VI) in a separate beaker and not including the concentrations of solutions or the pressure of hydrogen.

Only about half of the candidates were able to deduce the mole ratio of $\text{S}_2\text{O}_3^{2-}:\text{Cr}_2\text{O}_7^{2-}$ from two of the equations given. There were some excellent answers to the final unstructured redox titration calculations, with the working clearly explained. All candidates should have been able to score two marks for calculating the moles of thiosulfate ions and the initial moles of dichromate(VI) ions but some did not attempt these steps. Common errors included: omission of the subtraction to determine the number of moles of dichromate(VI) ions that reacted with ethanol, not using the dilution factor and using an incorrect molar mass for ethanol.

In order to improve their performance, candidates should:

- read the question carefully and make sure that you are answering the question that has been asked
- learn the meanings of all the key terms in the specification
- show all your working for calculations
- practise writing formulae of compounds
- check to make sure that equations are balanced
- practise combining half-equations to give an overall equation for a reaction
- draw all of the atoms and bonds on displayed formulae of organic compounds
- be careful how you draw curly arrows in organic mechanisms
- revise the reaction between amines and halogenoalkanes
- revise how to draw the structure of a polyester
- practise drawing diagrams of electrochemical cells.