A-LEVEL
CHEMISTRY

7405/1 Inorganic and Physical Chemistry
Report on the Examination

7405
Autumn 2021

Version: 1.0

Further copies of this Report are available from aqa.org.uk

General Introduction to the Autumn Series

This has been another unusual exam series in many ways. Entry patterns have been very different from those normally seen in the summer, and students had a very different experience in preparation for these exams. It is therefore more difficult to make meaningful comparisons between the range of student responses seen in this series and those seen in a normal summer series. The smaller entry also means that there is less evidence available for examiners to comment on.

In this report, senior examiners will summarise the performance of students in this series in a way that is as helpful as possible to teachers preparing future cohorts while taking into account the unusual circumstances and limited evidence available.

Overview of Entry

The paper was able to differentiate between students of differing ability. More able students were able to demonstrate their understanding well. All questions were answered correctly by some students. There was no evidence to suggest that students were short of time to complete the paper.
Definitions were generally poorly answered. Equations were often unbalanced and state symbols were sometimes incorrect or missing. Most students attempted all calculations; more able students could work through extended calculations well.

Comments on Individual Questions

Question 1

Most students could not recall the definition in question 01.1; students rarely referred to constant pressure and many referenced energy but not heat. Question 01.2 was generally well answered; common errors involved lack of balancing charges and omission of state symbols. In question 01.3 many students missed one or both factors of 2. Students found question 01.4 challenging; errors included lack of state symbols, equations written the wrong way around, enthalpy of lattice dissociation or formation equations, and equations with water not cancelled out. Many students answered question 01.5 well. Common errors in answers, however, included the wrong sign for the enthalpy change and omitting the factor of 2. Few students scored both marks for question 01.6; common errors included discussing the atomic radii of the ions, shielding and the distance of outer electrons to the nucleus. Very few students discussed the attraction of the ion to water.

Question 2

Many students answered question 02.1 well; a few students discussed the mass instead of the mass number, and some gave a definition of relative atomic mass. In question 02.2, the most frequent error was the number of electrons in the ion. A significant number of students were unable to produce an appropriate algebraic expression in question 02.3 and many did not include a term for the ^{48}Ti isotope. Those who could write a correct expression went on to give the percentage of the ^{48}Ti isotope and didn't give the percentage of the ^{46}Ti isotope. Only the most able scored all the marks in this question.

Question 3

Some students omitted the state symbols from the equation or missed out one of the state symbols in an otherwise correct equation in question 03.1; some students incorrectly gave oxygen or sodium oxide as a product. Most students appreciated that the reaction would be more violent and that the glass might shatter. In question 03.2 some students started from P_2O_5 and some gave H_3PO_3 as a product. Many gave the pH to be 2 which wasn't low enough to be given a mark. Answers to question 03.3 were generally quite good. The structure and bonding in silicon dioxide was generally well done but some students discussed forces between silicon dioxide molecules. The structure for phosphorus(V) oxide was less well known; the term molecular was given only in the best answers. Some students did not state that van der Waals' forces were between molecules. Students found question 03.4 challenging. A range of answers was seen for the oxide; students who gave the correct formula of aluminium oxide often failed to give a correct balanced equation. Question 03.5 was answered well, though common errors included calcium hydroxide or an incorrect formula for magnesium hydroxide. Although many students gave the correct answer in question 03.6, chlorine and argon were common incorrect answers.

Question 4

In question 04.1 most students stated that a heterogeneous catalyst is in a different phase to the reactants or described what a catalyst is or how it works. Students gave better answers for stage 2 than for stage 3; in stage 3 many students knew that active sites were blocked but did not state that this was poisoning and didn't explain how the efficiency of the catalyst could be improved. Several students confused the efficiency of the catalyst with conditions needed to maximise the yield or to speed up the reaction. In question 04.2 most students stated that ions of the same charge would repel, but fewer stated that the activation energy would be high. The equations were not well known. In question 04.3 many students stated that zinc had a full d sub-shell or had $3d^{10}$ configuration but did not explain how that related to the oxidation states of zinc. Some students completed the calculation well in question 04.4; common errors included identifying the limiting reagent as iron and then using the amount of iron (in moles) in the calculation, or stating that hydrochloric acid was the limiting reagent but not realising that this then controlled the amount of hydrogen produced. Some students converted the temperature and pressure incorrectly. In question 04.5 the colour of iron(II) carbonate was well known; however, if iron carbonate was given in words the (II) was often missing. The colour and/or formula were generally known in question 04.6 but the equation was not answered well; if the species were correct the equation was often not balanced. Students found question 04.7 very challenging; students often discussed the charge-to-size ratio of the hydrated ions rather than the iron ions themselves. Students rarely gained the second mark but a few did state that more hydrogen ions were released and so gained the third mark.

Question 5

Question 05.1 was generally well answered. Some students did not gain the first mark because they did not state a change in yield; a common error was to refer to equilibrium shift. Many students did not gain the third mark as they did not refer to the equilibrium shifting to oppose the decrease in pressure. About half of the students answered question 05.2 very well but others found the question very challenging; many students could not calculate the amount, in moles, of SO_2 and O_2 at equilibrium or omitted the amount of SO_3 when calculating the total amount, in moles, at equilibrium. Although question 05.3 was often well answered, common errors included not giving an expression for K_p, or giving an expression for K_p that used square brackets instead of partial pressures. Many students did the calculation well but some failed to use the squared terms from their expressions; units were sometimes given as concentrations rather than in terms of kPa. Just over half the students gave the correct answer in question 05.4.

Question 6

Students found question 06.1 challenging; many students stated that [H_2O] is 1 or [H_2O] has no effect. Some students appreciated that the concentration of water is included in the equilibrium constant. In question 06.2 some students realised that the reaction was endothermic but did not complete their answer with an explanation. Some students tried to explain their answer in terms of kinetics. Answers to question 06.3 were generally well done; a few students used ( ) brackets in the expression rather than [ ] brackets and a few students did not give the pH to two decimal places. Some students could not give a correct explanation. Almost all students answered question 06.4 correctly. In question 06.5 most students knew that the solution would be contaminated. Students found question 06.6 very challenging; most students said the titration would be more precise or accurate. Very few students explained clearly that a small volume of added alkali gives a large change in pH. In question 06.7 many students related the colour changes to the equivalence point or the endpoint without using the curve. Most students calculated the amount of hydrogen and hydroxide ions correctly in question 06.8; common errors, however, included not calculating the excess amount of hydroxide ions and not dividing by the volume of solution.

Question 7

In question 07.1 most students explained that gases are more disordered; a few students explained the disorder in terms of the number of atoms in the molecule rather than using the physical state of the substances. Answers to question 07.2 were poor; common errors included 0 with no units, 298 K and +/-273 K. Question 07.3 discriminated well. Several students reversed the expressions for change in enthalpy and change in entropy and gained negative values; some students did not convert the change in entropy to the correct units and some tried to convert the temperature in Kelvin into degrees Celsius. Most students could give a correct expression involving ΔH, ΔS and T.

Question 8

Few students gave a correct answer to question 08.1; some students explained that it was a list of electrode potentials but failed to state that these were in order and a few students used the idea of EMF or cell potentials rather than electrode potentials. Conditions in question 08.2 were well known but some students only gave one condition; 101 kPa or 1 atm were the commonest wrong answers. In question 08.3 many students gave $[Co(H_2O)_6]^{3+}$ as the ion; Fe was also a common incorrect answer. In question 08.4 many students did not start with Fe but with $[Fe(H_2O)_6]^{2+}$; those who started with Fe often gave Fe^{2+} or $[Fe(H_2O)_6]^{2+}$ as the product. Students who gave an equation often failed to cancel out the waters on each side of the equation. Very few students gave the explanation correctly in question 08.5. Some students gave the equation correctly; a significant number, however, thought the cobalt complex was a reducing agent and gave iron as the product. In question 08.6 many students realised that the ligands were different.

Question 9

Students found question 09.1 very challenging. Some students stated that lithium reacts with water but only a very small number of students could give an explanation in terms of electrode potentials. Answers to question 09.2 were generally correct. In question 09.3 some students realised that the cell was operating under non-standard conditions. Many students could calculate the oxidation state in question 09.4; however common errors included –7 and +9. Very few students knew the equation in question 09.5. The equation in question 09.6 was slightly better, but many students reversed the equation and some had electrons on the wrong side of the equation.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.