GENERAL COMMENTS

The two most common general problems for students resulted from errors in their reading and writing.

Reading

A significant number of student errors arise from apparent misunderstanding or ignoring of instructions given in a question. A simple example occurred in Question 6d, the last sentence of which stated 'Be careful to use the correct number of significant figures in your answer'. A surprising proportion of otherwise correct answers failed to address this simple instruction and thus lost 1 mark. A more complex example was illustrated by the answers to Question 4b which said 'State Le Chatelier's principle.' The response asked for the statement of a 'principle', i.e. a generalisation. Although this was quite well done by many students (the average score was almost 70%), many chose to respond by giving only a specific illustration of Le Chatelier's principle. Such answers received a mark, but could not be given full marks.

Some of these apparent reading errors may be due to the inevitable time pressures of the external examination – students rushing to get a question finished and not having time to read it properly. Other errors may arise from a lack of prior preparation combined with a student's difficulty in quickly constructing sentences to explain an idea or concept that may be understood, so that a less than appropriate response is used to fill the gap.

Writing

As noted in Question 1d of the 2001 report on Examination 2, 'Many students revealed little understanding of the bomb calorimeter'. This illustrated the point that some prior practice with the concepts being examined is a big help in giving students the opportunity to order their thoughts in advance. This same point was equally well illustrated in Question 1a in this examination. The question was fairly well done with an average score of a little over 60%. However, as is common with questions requiring students to explain something 'in their own words', assessors were instructed to be generous. At times assessors, found themselves trying to read the mind of a student and giving partial credit for a few appropriate headings when it seemed likely that the student knew what was going on, but could not put his/her concepts into coherent English. Question 1a this year generated responses that ranged from absolutely perfect summaries of the nature and use of gas chromatography (sometimes pre-learned no doubt) to garbled responses that sometimes confused gas chromatography with High Performance Liquid Chromatography. The latter were the most difficult to decipher, since credit is given for all 'correct' material. It was necessary to try and distinguish between clearly incorrect material (no marks) and the material from a student who probably did know what gas chromatography was about, but had expressed it in a disordered and often confusing fashion.

Teachers need to give students practice in answering questions of this nature and reviewing and discussing these answers in class.

SPECIFIC INFORMATION

Section A – Multiple choice questions

This table indicates the approximate percentage of students choosing each distractor. The correct answer is the shaded alternative. Comments are given on ten items in the multiple-choice section including the eight items with a less than 50% average score.

Question	A	B	C	D	
1	6	15	26	52	
2	6	7	73	14	
3	4	5	9	82	
4	52	13	12	23	
5	13	5	79	3	
6	44	32	19	5	Students selecting A, made the mistake of omitting to note that, when the 0.010 mol of $CCl_3CH(OH)_2$ dissociated to give 0.002 mol of each of two products, then there would be only 0.008 mol of $CCl_3CH(OH)_2$ left.
7	11	33	27	28	Given the small *K* and the fairly high concentrations of the reactants, it should have been evident that there would only be low concentrations of product at equilibrium. This should have eliminated A and C immediately. But D was a trap for many – since 4 mole of HCl was produced for every mole of O_2 produced it should have been clear that the HCl concentration was four times higher than the O_2 concentration, i.e. $4[O_2] = [HCl]$. The stoichiometric equation was quite a trap.
8	18	24	24	34	The frequency of responses for B and C suggested that many students wanted to halve the equilibrium constant rather than take its square root.
9	12	65	20	3	

10	7	12	23	58	
11	87	6	6	2	This elicited the highest correct response rate for any multiple-choice question – one that was not thought to be a particularly easy one. Students are well able to calculate oxidation numbers.
12	19	66	8	6	
13	17	5	73	6	
14	10	30	9	50	Many still find this difficult. The high frequency of the incorrect response B is attributed to students believing that K_w is always 10^{-14} whatever the temperature. The important point to see here is that $[H^+]$ and $[OH^-]$ in pure water must always be the same, whatever the temperature.
15	52	15	25	8	
16	39	38	14	8	From student knowledge of the preparation of sulfuric acid, it should have been clear that the production of SO_3 from SO_2 is not favoured by high temperatures (as in a flame). In any event, it is very well known that SO_2 is a common pollutant arising from the burning of coal with a high sulfur content.
17	14	36	27	22	C and D were both common incorrect responses. In C, students divided the 40 000 relative molecular mass by 12 (for C) rather than 14 (for CH_2). In D, the number of atoms in a mole was given – not the number in a molecule (an example of not reading the question carefully enough).
18	13	35	42	10	A large number of students thought that N_2 could not be successfully dried by sulfuric acid. This seemed odd, particularly with ammonia sitting there beneath it.
19	11	27	32	29	There were two points in particular that caused consternation. The limiting reactant was O_2 so that there could never be any more than 2 mole of SO_3 produced. Secondly, this is an equilibrium system so that there would always be a bit less that 2 mole of SO_3 present at equilibrium.
20	39	30	20	11	The point of using the well-insulated container was to ensure that the heat of reaction remained with the reactants and products. Since the reaction is given as exothermic, clearly the reaction mixture must rise in temperature and the position of equilibrium must therefore shift to the left. Perhaps the use of 'same size' in the stem stuck in the minds of those who chose A and they did not think any more about the significance of 'well-insulated'.

Section B

This part of the report is based on the marking scheme and for simplicity, molecular structures are omitted. The details include a particular emphasis on the importance of ensuring that 'consequential' errors are not penalised. Assessors are required to check student calculations in cases where a mistake has been made by a student in an early part of a question and the mistaken response then used in a subsequent part.

Note: **Significant figures** were only to be considered in 6d. **States** were considered only in 7bii, cii and ciii.

Question	Marks	%	Response
Question 1	**a**		Mobile phase → N_2 (or equivalent indication).
	0/4	16	Stationary phase → shaded part of U-tube.
	1/4	10	
	2/4	18	Components of mixture are adsorbed to differing extents by stationary phase so rate of movement through the tube is determined by the extent of adsorption.
	3/4	16	
	4/4	40	
	b		Solvent, Stanozolol.
	0/2	41	
	1/2	40	When a student responded 'only one peak' and then asserted that there was only one substance present, 1 mark was awarded.
	2/2	19	
	c		Mix suspect sample with pure Stanozolol and then verify that only one peak is obtained (or, compare retention times). Surprisingly a significant number of students had the idea that this was somehow related to mass spectrometry and suggested that there were 'many peaks because the molar mass is so large'.
	0/1	44	
	1/1	56	
Question 2	**a**		Substitution (or chlorination, oxidation).
	0/1	23	
	1/1	77	
	b		Catalyst.
	0/1	28	
	1/1	72	This was the best response given what was required by the question. The light dissociates the Cl_2 and the resultant Cl atoms then abstract an H atom from the alkane

			giving HCl and an alkyl free radical. The free radical then pulls a Cl atom off another Cl_2 molecule and generates another Cl atom and so on; however, that is all beyond what is required so the simple response 'catalyst' was accepted.
	c 0/1 1/1	 40 60	HCI
	d 0/3 1/3 2/3 3/3	 4 5 16 75	$CH_3CH_2CH_2Cl$; $CH_3CHCl.CH_3$; 1- or 2-chloropropane as appropriate. This was extremely well done.
Question 3	**a** 0/1 1/1	 8 92	$K = [OH^-][H_3BO_3]/[BOH)_4^-]$.
	bi-ii 0/4 1/4 2/4 3/4 4/4	 32 12 11 20 25	**bi.** $[H^+] = 10^{-11.11} = 7.76 \times 10^{-12}$ M; $[OH^-] = 10^{-14}/7.76 \times 10^{-12} = 1.29 \times 10^{-3}$ M. **bii.** $[H_3BO_3] = [OH^-] = 1.29 \times 10^{-3}$ M.
	c 0/1 1/1	 65 35	$K_a = (7.76 \times 10^{-12} \times 0.100)/1.29 \times 10^{-3} = 6.01 \times 10^{-10}$.
Question 4	**a** 0/1 1/1	 18 82	24 – 1%.
	b 0/2 1/2 2/2	 21 22 57	A system at equilibrium will shift so as to minimise the effects of any change in external conditions imposed on it.
	c 0/2 1/2 2/2	 15 10 75	Raising the temperature has reduced the proportion of ammonia at equilibrium, therefore the reaction as given is exothermic.
	d 0/1 1/1	 32 68	Reaction rate may be too slow at lower temperatures.
Question 5	**ai** 0/2 1/2 2/2	 34 11 56	mol of CO_2 = 2.20/44 = 0.050; mass of C = 0.050 x 12 = 0.60 g (= 0.05 mol C).
	aii 0/2 1/2 2/2	 39 16 46	mol of H_2O = 0.90/18 = 0.050; mass of H = 2 x 0.05 x 1 = 0.10 g (= 0.10 mol H).
	aiii 0/1 1/1	 61 39	mass of O = 1.02 - 0.60 - 0.10 = 0.32 g. Having often got i and ii correct, many students then failed to see that oxygen had to be calculated by difference. This is a good point to emphasise in solving this type of question.
	aiv 0/2 1/2 2/2	 46 13 41	No. of mole of O = 0.32/16 = 0.020. Empirical formula: C (0.050) : H (0.10) : O (0.02) = $C_5H_{10}O_2$.
	b 0/2 1/2 2/2	 63 8 29	16.0 g O_2 is 0.50 mol of O_2, thus 51.0 g of the unknown compound will be 0.50 mol. The molar mass of the compound is 51.0 x 2 = 102 g mol^{-1} .
	c 0/1 1/1	 77 23	$C_5H_{10}O_2$.
	d		Any one of: $HCOOCH_2CH_2CH_2CH_3$; $CH_3COOCH_2CH_2CH_3$; $CH_3CH_2COOCH_2\ CH_3$;

	0/1 74 1/1 26		$CH_3CH_2CH_2COOCH_3$. Having failed to find the correct response in c, students could still gain a mark by identifying a correct structure for an ester. Students should always be reminded that they are never penalised for 'consequential' errors when they continue on in a complex problem. Quite a few students picked up marks for giving the correct structure of an ester.
Question 6	**a** 0/4 3 1/4 2 2/4 7 3/4 26 4/4 62		***Please see table below***
	b 0/1 70 1/1 30		So as not to use too large a volume of the NaOH solution (or to use and obtain a reasonably sized titre).
	c 0/1 21 1/1 79		To minimise the error (or to ensure reliability).
	d 0/4 27 1/4 13 2/4 17 3/4 19 4/4 24		Concentration of titrated vinegar = (0.11 x 15.35)/20.00 = 0.0844 M. Since the initial dilution of vinegar is 10, giving the concentration of undiluted vinegar is 0.84 M. The final result needed to be given to exactly **two** significant figures.
Question 7	**a** 0/1 16 1/1 84		Fractional distillation.
	bi-ii 0/2 11 1/2 29 2/2 59		**bi.** Cracking. **bii.** C_8H_{18} (g) $\rightarrow$ C_2H_4 (g) + C_6H_{14} (g) (or equivalent).
	ci-iii 0/3 19 1/3 23 2/3 28 3/3 30		**ci.** Having a double bond. **cii.** C_2H_4 (g) + $3O_2$ (g) $\rightarrow$ $2CO_2$ (g) + $2H_2O$ (g). **ciii.** C_2H_4 (g) + H2 (g) $\rightarrow$ C_2H_6 (g) (or equivalent with H_2 replaced with H_2O, HCl, Cl_2, etc).

Question 6a

glassware used	rinse with water	rinse with diluted vinegar solution	rinse with NaOH solution
volumetric flask	✔		
burette			✔
20.00 ml pipette		✔	
conical flask	✔		