Chemistry: Written examination 1

GENERAL COMMENTS

The new examination criteria used for the first time in 2000 were:

1. understanding of qualitative and quantitative aspects of chemical reactions, including acid-base and redox reactions and their application in the analysis of a variety of consumer products by a range of common laboratory techniques and modern instrumental methods
2. understanding of the principles of equilibrium, reaction rate and energy change and their relationships to the outcomes of chemical reactions, including those in living systems and small scale laboratory reactions
3. understanding of chemical reactions and the relevant concepts in the production of important industrial chemicals, including sulfuric acid and substances derived from petroleum
4. knowledge of experimental measurement and observations
5. analysis, interpretation and synthesis of information.

Items 3 (27% correct), 5 (35%), 12 (45%) and 20 (42%) discriminated effectively in favour of good students. Item 13 (16%) also discriminated at the upper end of the scale, but the spread of responses over the distractors in Item 13 indicated a need for more effective learning about rate and yield in equilibrium reactions.

Section A

Item	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Correct response	% of correct responses	Area of Study reference
1			✓			**B**	79	3.3
2			✓			**C**	44	3.3
3	✓					**D**	27	2.10
4	✓					**B**	76	2.10
5	✓					**C**	35	2.10
6	✓			✓		**B**	91	1.5
7	✓			✓	✓	**B**	78	1.5
8	✓					**C**	67	1.4
9	✓					**B**	48	1.4
10	✓			✓	✓	**D**	63	1.5, 1.6, 1.7
11		✓			✓	**B**	49	2.6, 2.9, 2.10
12		✓			✓	**C**	45	2.3, 2.6
13		✓	✓			**C**	16	2.7, 3.1
14		✓				**B**	74	2.4, 2.5, 3.1
15		✓				**A**	78	2.1, 2.2
16		✓			✓	**A**	63	2.6, 2.7
17			✓			**B**	84	3.2
18			✓			**A**	54	3.3
19	✓					**C**	64	1.2, 3.1
20	✓					**D**	42	2.8

SPECIFIC INFORMATION

Item 3

Only 27 per cent gave the correct response (D). Forty-six per cent gave response C which would have been correct if barium hydroxide had only *one* hydroxide ion per mole. A very simple item that indicated students have only a fragile grasp of stoichiometric principles.

Item 5

Thirty-five per cent gave the correct response (C). It is noteworthy that 24 per cent chose D, which would be obtained by 'arithmetically averaging' the pH values of the two solutions mixed – clearly some moderately good students chose this, perhaps due to a lack of understanding of the principles of logarithms.

Item 11

This was thought to be a very difficult question. It required a three stage calculation – conversion of a pH to a concentration, perceiving that the nitrite ion concentration was the same as the hydrogen ion concentration and then applying the equilibrium law. An impressive 49 per cent correctly chose B.

Item 12

Forty five per cent correctly chose C. Students were required to combine a simple calculation of concentration with an ability to formulate the equilibrium law.

Item 13

Sixteen per cent of students gave the correct answer. Many who did not were otherwise high-achieving students. The most popular response was B (42%), where the respondents presumably confused the rate at which equilibrium could be achieved with the extent to which the reaction would proceed, i.e. the yield. Forty-five per cent got the high temperature right (A or C) but only half realised that the low flow rate would allow greater contact time with the catalyst and hence a more rapid achievement of equilibrium.

Item 16

Sixty-three per cent got the correct response (A) confirming (see Section B Question 6) that students now handle problems requiring the application of Le Chatelier's principle very well indeed.

Item 18

Fifty-four per cent correctly chose A. The next most popular choice was B which was methyl propanoate. In other words, over seventy per cent of the students correctly identified the correct hydrocarbon fragments – but a significant minority got the functional group 'back to front'.

Item 20

Forty-two per cent correctly chose D. It required students to perceive that an equilibrium constant was indeed a constant at a particular temperature. (Compare them to the other more 'predictable' equilibrium questions such as Item 16 and Section B Question 6.)

Section B

Question	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Average mark	Area of Study reference
1	✓			✓		3.47/7	1.4
2	✓				✓	4.54/8	1.3, 1.6
3			✓			2.57/4	3.2, 3.4
4			✓			a–b 3.50/6 c 3.74/5	3.2, 3.3
5				✓	✓	a–c 1.79/4 d 1.49/3	1.1, 1.2, 1.3
6		✓				5.16/7	2.1, 2.2, 2.3, 2.5, 2.6, 2.7

Marking scheme with comments (* = 1 mark)

Question 1 (7 marks)

a. (2) Any two** of: Chemically stable; accurately known composition; high molar mass; soluble in water; solid at room temperature, cheap/reasonable price.

b. (5) Mole of Na_2CO_3 required = (250/1000) x 0.1 = 0.025 mole*. Mass of Na_2CO_3 required = 106 x 0.025 = 2.65 g*. Sequence to follow: weigh out 2.65 g of a dried sample of the Na_2CO_3*; transfer all the solid into a standard 250.0 mL volumetric flask*; dissolve the Na_2CO_3 in the water in the flask and make up to the mark on the neck of the flask*.

The question explicitly asks students to 'include in your answer the relevant calculations ...'. A high number of students managed 2 marks from 2a, but then failed to calculate that 2.65 g of sodium carbonate was needed – or even to show how to calculate the mass of sodium carbonate needed. The quality of the descriptions of how to prepare the required solution suggested that many students had not actually carried out such a procedure in the laboratory; notwithstanding a generous interpretation of the marking scheme, it was not possible to reward those who wanted to use graduated cylinders to determine the volume, or those who added solid to 250 mL of water. Another comparatively common error was to jump to the conclusion that, since the process had something to do with the standardisation of an acid, then HCl must be involved. Quite a few students seemed to think they were describing the production of a standard HCl solution. Some practice at verbalising the process required for the preparation of standard solutions could be the basis of a useful learning experience for many students.

Question 2 (8 marks)

a. (4 marks) $V = nRT/p$* = (2* x 8.31 x 773)/101 325 = 0.1268 m^3 = 126.8 L*. Volume per second = 126.8/6* = 21.1 L s^{-1}.

b. (1 mark) Particle size will be a major factor in determining the rate of a solid-solid reaction* (because of higher surface area available).

c. (3 marks) Light is emitted by excited metal ions* as they drop from a high electronic energy level to a lower energy level.* The colour (wavelength) of the light depends on the energy of the radiation and hence on the particular metal ion.*

A fairly well-done question. The ideal gas calculation was generally well handled and provided half the marks for the question. A mention of 'particle size' was enough to gain the mark in part b. The answers to part c. were of highly variable quality and the marking had to be quite lenient. The idea that light was emitted as an electron dropped from an excited state to a lower energy state was only rarely expressed clearly. It would be useful if this point was made quite explicitly and students were encouraged to verbalise what is a difficult concept.

Question 3 (4 marks)

a. (1 mark) Fractional distillation*.

b. (1 mark) Cracking*.

c. (1 mark) H_2*.

d. (1 mark) $n\,C_2H_4(g) \longrightarrow -CH_2CH_2CH_2CH_2CH_2CH_2CH_2-$*

A generally easy one, but students were either clearly 'right' or 'wrong'.

Question 4 (11 marks)

a. (4 marks) Q* = ethane, CH_3CH_3; R* = ethene, CH_2CH_2; S* = ethanol, CH_3CH_2OH; T* = ethyl ethanoate (or ethyl acetate), $CH_3COOCH_2CH_3$ (half a mark for each of the eight points to be made rounded **down**, where necessary, to the nearest integer; semi-structural formulas are acceptable).

bi. (1 mark) any appropriate strong oxidising agent, e.g. $K_2Cr_2O_7$* (O_2 is acceptable).

bii. (1 mark) $H^+(aq)$, or the formula of a strong acid.*

Quite well done. The most common errors were in getting the reagents for the oxidation and the hydrolysis wrong.

c. (5 marks) Addition*; addition*; condensation*; substitution*; substitution*.

Perhaps the easiest part of the paper, as quite a few students who otherwise did quite poorly on the paper still managed a respectable score for this question.

Question 5 (7 marks)

a. (1 mark) volume of ethanol in one bottle = (13.5/100) x 750 = 101.25 mL = 101 mL*.

b. (2 marks) mass of ethanol in one bottle = 101.3 x 0.790* = 79.9875 = 80.0 g. Mass of ethanol in one standard drink = 80.0/8 = 10.0 g = 10 g*.

c. (1 mark) $H_2O(l) + C_2H_5OH(aq) \longrightarrow CH_3COOH(aq) + 4H^+(aq) + 4e^-$* (must be balanced).

These standard stoichiometry calculations attract a similar level of performance each year; either students know how to do it or not. Of those who more or less understood what was needed, the common errors were as much due to general confusion or even simple arithmetic errors as to problems with a particular step in the calculation. ***Note***: general practice is that, arithmetic errors are only penalised once – consequential numerical errors are then ignored.

di. (1 mark (20.61/1000) x 0.0750 = 1.55 x 10^{-3} mol*.

dii. (1 mark) 1.55 x 10^{-3} x (3/2) = 2.32 x 10^{-3} mol* ethanol.

diii. (1 mark) 2.32 x 10^{-3} x (250/25) = 2.32 x 10^{-2} mol*.

The fact that part d. was 'easier' than parts a–c. was evidence that errors in a–c. were often arithmetic (or due to the misuse of significant figures, which cost many 1 mark). Consequential errors from a–c. were discounted here. Note that misuse of significant figures was penalised once only per paper so that no more than 1 mark for the whole paper could be lost in this way.

Question 6 (7 marks)

a. (6 marks) decrease*; increase*; increase*; increase*, decrease*, increase*

d i i

i d i

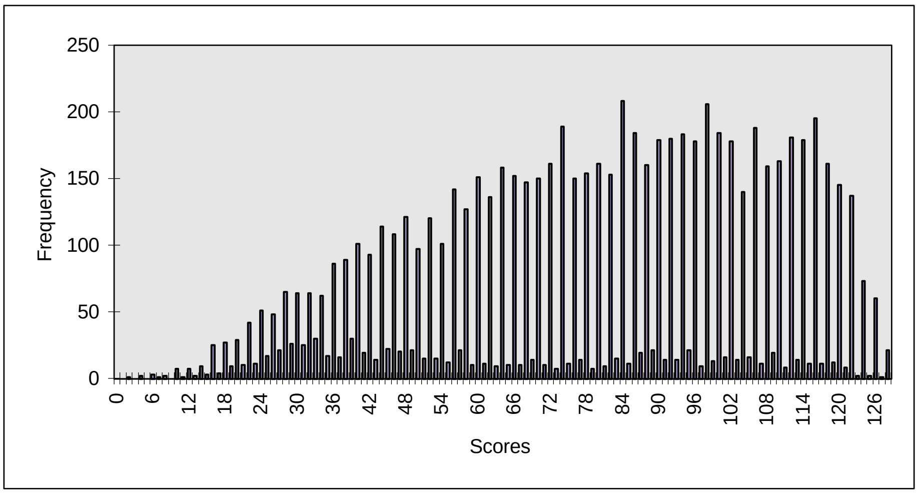
b. (1 mark) line should show a quantitatively opposite change in the number of mole of methanol*.

Most students find it comparatively straightforward recalling Le Chatelier's principle and applying it (see Item 16 in Section A).

CH031 CHEMISTRY WRITTEN EXAMINATION 1

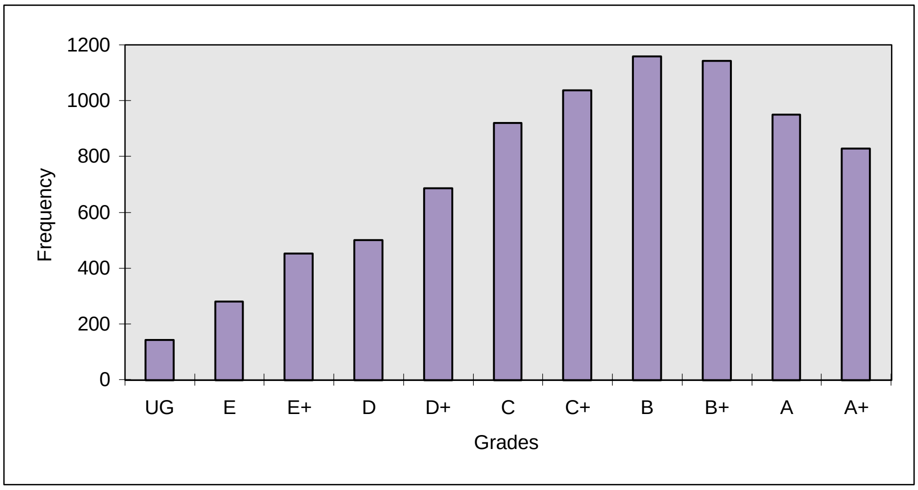
HISTOGRAM OF TOTAL SCORES 2000

Count 8097 Mean 78.48 Standard Deviation 28.48 NA Result 96



HISTOGRAM OF TOTAL GRADES 2000

Count 8097 Mean 6.21 Standard Deviation 2.60 NA Result 96



ENROLMENTS		%
Female	4434	54.1
Male	3760	45.9
Total	8194	

GLOSSARY OF TERMS

Count Number of students undertaking the assessment. This excludes those for whom NA was the result.

Mean This is the 'average' score; that is all scores totalled then divided by the 'Count'.

Standard Deviation This is a measure of how widely values are dispersed from the average value (the mean).