

Chemistry CAT 1: Written examination

GENERAL COMMENTS

The general structure of this CAT is now well understood by teachers. The current assessor training procedures are excellent. Assessors are first led through the marking scheme by the Chief Assessor, then mark and publicly discuss two complete composite papers made up of questions selected by the Chief Assessor and Assistant Chief Assessor. Having then agreed on both the marking scheme and its interpretation, all assessors complete trial marking of a common set of scripts. Assessor performance data for the Chief Assessor is then provided by the Board within an hour so that deviations from the marking standard required can be immediately identified and dealt with by detailed person-to-person discussion with the Chief Assessor. This procedure, coupled with the use of control scripts for monitoring assessor performance during the marking process, is probably about as fair a system as it is possible to devise.

SPECIFIC INFORMATION

Question 1 (possible 4 marks)

- a. (1) $\text{Br}_2(\text{aq}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$
- b. (2) $\text{H}_2\text{S}(\text{aq}) + 4\text{H}_2\text{O}(\text{l}) \rightarrow \text{SO}_4^{2-}(\text{aq}) + 10\text{H}^+(\text{aq}) + 8\text{e}^-$
(1 mark for a sensible attempt with the correct reactants on both sides, but failing to 'balance'.)
- c. (1) $4\text{Br}_2(\text{aq}) + \text{H}_2\text{S}(\text{aq}) + 4\text{H}_2\text{O}(\text{l}) \rightarrow \text{SO}_4^{2-}(\text{aq}) + 10\text{H}^+(\text{aq}) + 8\text{Br}^-(\text{aq})$ ('all or nothing')

A straightforward question requiring the ability to provide balanced half equations. Part a was correctly answered by most students. Part b required more than the ability to look up the half equation in the Data table and was poorly done. Although full marks for part c were available if a 'wrong' part b equation was combined with a correct answer to part a, very few managed this.

Question 2 (possible 11 marks)

- a. (6) Acceptable errors include any three of:
- Felt tip pen 'ink' will/may contain colorings that may interfere with the proposed study (use pencil, or a scratch on paper).

- A spot 10 mm in diameter would be unnecessarily large (place small spot covering small area).
- The spot must not be covered by solvent (spot must be clear of the solvent surface).
- The component that absorbs most strongly will not pull itself furthest up the paper (spot that has moved the most will be the one least strongly adsorbed on the paper).

Quite well done in general – very few students missed the last point given above. A significant number of students stated that the drop of food colouring should not be allowed to dry while others stated that the chromatograph should be stopped 'well before' the solvent front reached the top of the paper. Neither of these responses was accepted as correct.

- b. (2) The R_f value is calculated as the ratio $R_f = (\text{distance between spot and the spot starting position} / \text{distance between solvent front and the spot starting position})$. One mark for a ratio between the final spot position and a starting position. One mark for a clear definition of just what the starting position is, e.g. don't accept the starting position of the solvent front as a correct definition of the 'starting position'.

Credit was given in all cases where the student illustrated the calculation of R_f with a diagram. Indeed, this was the more common form of response.

- c. (1) mixture to be separated in a mobile phase (solvent, gas)
(1) stationary phase that differentially adsorbs the components of the mixture in the mobile phase
(1) rate of motion of components of mixture depends on degree of adsorption, hence separation.

Responses to part c were patchy indicating that a high proportion of students find it difficult to summarise the basic concepts into a verbal description. This type of question is challenging for markers who, in looking for key words like 'mobile', 'stationary', 'adsorption'have to exercise thoughtful judgment as to whether they have been used in a meaningful fashion while at the same time making allowance for difficulties with the English language.

Question 3 (possible 13 marks)

- a. (1) $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$ OR $2\text{Fe}_2\text{O}_3(\text{s}) + 3\text{C}(\text{s}) \rightarrow 4\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$
- b. (2) $\text{O}_2(\text{g})$ generates the reductant $\text{CO}(\text{g})$ by reacting with carbon
 $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g})$
- c. (2) $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
- d. (1) $\text{Fe}(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{FeSO}_4(\text{aq}) + \text{H}_2(\text{g})$ OR $\text{Fe}(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{H}_2(\text{g})$
- e. (3) $\text{H} = +1$; $\text{S} = +6$; $\text{O} = -2$
- f. (2) i. one of: dust, noise, CO_2 , thermal pollution.....
 ii. one of: SO_2 release.....
- g. (2) i. one of: construction material..... one of: synthesis of fertilisers, car battery acid.....

Another example where an ability to write equations was a key; parts a, b and c were routine. Part d; very few had any idea of the correct answer, yet could have deduced it from the Data tables. This may perhaps illustrate a general difficulty in writing ionic equations. Parts f and g should have been 'gimmies', but some answers were very hard to credit. The use of sulfuric acid in the synthesis of fertilisers was fair enough, but many said more or less directly that 'sulfuric acid is used as a fertiliser'!!! It is apparent that some students expected markers to interpret the single word 'fertiliser' to mean 'sulfuric acid is used in the manufacture of fertilisers', but that does put a lot of pressure on a marker who has just seen another student write something like 'as a fertiliser'. Students should always be advised not to make it hard for the markers by writing a single word answer where a short phrase would have made it quite clear.

Question 4 (possible 6 marks)

- a. (1) $\frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ ('all or nothing')
- b. (1) $24 \pm 1\%$
- c. (1) A system at equilibrium will respond to any change in its conditions that can affect the position of equilibrium, so as to minimise the effects of that change ('all or nothing').
- d. (2) The % conversion at equilibrium decreases (1 mark) with increasing temperature, hence the reaction for the production of ammonia must be exothermic (1 mark).
- e. (1) Reaction too slow under these conditions (1 mark).

A standard question – no surprises in the responses. Those that knew it, knew it. Those that didn't, didn't!

Question 5 (possible 8 marks)

- a. (3) Show flat plate surface with smears of grease adhering (1 mark); show hydrophilic and hydrophobic parts of detergent molecule (1 mark); show hydrophobic part stuck in grease and hydrophilic part in the water (1 mark).

Not badly done. Labelling was often sloppy or omitted, but where the labelling was 'transferred' to the diagrams drawn in part c, the marks were also awarded as if the part a diagram had been correctly labelled. It was not uncommon to find the hydrophobic and hydrophilic ends transposed so that the 'tail' was in the water and the 'head' in the grease – no credit was awarded for that error.

- b. (2) i. The water dipole (O^- , H^+) interacts by electrical attraction with the ionic or polar part of the detergent molecule (a diagram must make clear that + attracts - by showing correct orientation).
- ii. dispersion forces between hydrophobic part of detergent and the hydrophobic grease (1 mark).

Generally poorly done. Markers commented that some students did not interpret the question correctly and therefore did not concentrate on using the language of simple bonding theory that the marking scheme required.

- c. (2) Show formation of micelle-like structure (1 mark) with blob of grease 'solubilised' by detergent with the correct orientation (1 mark) of the hydrophobic and hydrophilic ends of the detergent ion or molecule.

Quite well done except for those who had the hydrophobic and hydrophilic ends transposed so that the 'tail' was in the water and the 'head' in the grease.

- d. (1) Liquefies grease, making it easier to disperse (1 mark)

Many answers attempted to relate the effect to the temperature dependence of the surface tension but that was not really what was wanted.

Question 6 (possible 8 marks)

- a. (2) $(8.20/1000)$ (1 mark) $\times 0.0500$ (1 mark) = 4.10 mole
- b. (1) $4.10\text{E} - 4 \times (3/2)$ (1 mark) = 6.15E - 4 mole
- c. (1) $6.15\text{E} - 4 \times (1000/25)$ (1 mark) = 0.0246 M
- d. (1) $0.0246 \times (500/20)$ (1 mark) = 0.615 M
- e. (2) 0.615×46 (1 mark) $\times (200/1000)$ (1 mark) = 5.66 g
- f. (2) Any two of: Safety glasses, lab. coat, gloves, pipette filler.....

Generally well answered. We have noted before that these straightforward stoichiometric problems appear to be well taught. No exception this year. Nonetheless, the question was a good discriminator.