

CHEMISTRY

REPORT FOR TEACHERS

CAT 1: Chemistry in a practical context

Question 1

The correct answers for the multiple-choice questions are:

- Q1 D Q11 D
 Q2 A Q12 A
 Q3 C Q13 A
 Q4 D Q14 B
 Q5 B Q15 C
 Q6 C Q16 C
 Q7 C A17 D
 Q8 A Q18 D
 Q9 B Q19 A
 Q10 C Q20 B

For the following questions each '*' indicates ONE mark for an answer.

Question 2: - 8 marks

- a. 2 $\frac{7.66}{2335} = 0.0328 \text{ mol}; *$ for the molar mass of BaSO_4 ; $*$ for the correct answer.
 b. 1 0.0328*
 c. 1 0.0328 x 96.1 = 3.15g*
 d. 1 $\frac{3.15}{40} \times 100 = 7.88\% *$ (by mass)

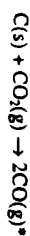
e. 2 wet ppt. would have a mass that was too high*, hence the calculated % would be too high*

f. since excess BaCl_2 was added initially and all the Ba was pptd., the addition of more BaCl_2 can have no practical effect on the amount of ppt formed*. (Credit may be given to a student who argues that the concentration of SO_4^{2-} in the volume-doubling experiment will be lowered so that a slightly smaller fraction of the SO_4^{2-} in the volume-doubling experiment will be lowered so that a slightly smaller fraction of the SP_2 is pptd. - but the argument must be very clearly set out).

Comment: This elementary stoichiometry question provided the easiest question on the paper. There were no specific problems identified with this item.

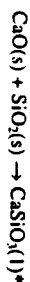
Question 3: - 8 marks

a. 2 i $\text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) *$



ii $\text{Fe}_2\text{O}_3(s) + 3\text{CO}(g) \rightarrow 2\text{Fe}(l) + 3\text{CO}_2(g) *$

iii $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g) *$



b. 1 coke plus oxygen* OR $\text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) *$

c. 1 makes it easy to remove* OR protects the liquid iron from atmospheric oxidation*

d. 1 improves energy efficiency* OR leads to lower cost production*

Comment: A straightforward question that rewarded any student who had learnt the equations. The positioning of the equation for the decomposition of CaCO_3 was 'accepted' at any of the three stages.

Question 4: - 11 marks

a. 2 diagram or statement noting net inward pull on molecule in surface*; identification of surface tension with need to break intermolecular bonding*. (The surface tension of a molecular liquid is the work needed to increase the surface area of a liquid by a standard amount. Increasing the surface area means increasing the number of molecules in the surface and hence breaking molecule-molecule bonding. Thus, the stronger this bonding, the higher the surface tension).

b. 1 method: measure the rise of each liquid in a capillary* OR measure the force needed to detach a ring or plate from the surface of each of the liquids*. (Note that there is no satisfactory method of measuring surface tension of a free surface by using the shape of a drop sitting on a surface; however, given that the shape of a drop of liquid on a surface is related to the surface tension of the liquid, a mark should also be given for suggesting that a drop of each liquid could be placed on a plastic surface and noting the much higher contact angle of the water*. Note also that a glass surface is unacceptable since water wets glass and has a contact angle of zero on this material).

1 expected observation: Capillary rise: liquid with higher surface tension will require more force to detach from liquid surface* (noting the larger contact angle observed for a water drop on a plastic or similar sheet*).

2 explanation of results: The results will show that water will show a higher surface tension than petrol* (this point may be validly made under 'expected observation'). Water has the higher surface tension because of the much stronger intermolecular bonding compared with that between the hydrocarbon molecules in petrol*. (If this question is interpreted in terms of the equipment used then marks may be awarded as follows: Capillary: stronger intermolecular forces leads to larger pressure difference* and hence greater capillary rise*. OR Ring detachment: stronger intermolecular forces lead to stronger attraction and hence greater force needed to detach ring*. OR Drop shape: stronger intermolecular forces lead to stronger attraction between molecules and hence drop approaches a more spherical or rounded shape).

c. 2 Molecules in the bulk liquid will have higher kinetic (thermal) energy at the higher temperature*, hence it will require less energy to transfer the molecule from the bulk into the surface*. (Note that in the case of water the average number of hydrogen bonds decreases with increasing temperature so that the intermolecular bonding becomes, on the average, weaker with increasing temperature. Credit should be given if this point is made. Note also

that, assuming the explanation given is otherwise adequate, students who assume that 'water' at 0°C is ice were not penalised.

d 1 i the high surface tension of the water then prevents the needle from passing through the surface.

2 ii detergent will cause the needle to be wetted so that it will sink*. surface active molecules attaching themselves to the needle surface make this possible* OR surface active molecules reduce the surface tension of the water* by orienting themselves in the surface so as to give an essentially hydrocarbon-like surface*.

Comment: This was the most difficult question on the paper to mark. The subject matter is complex and the material available to teachers and students can often appear baffling because qualitative descriptions of sophisticated concepts and techniques can lead students to make unintentionally incorrect assertions.

Very few students mentioned capillary rise and none to ring detachment as a method of measuring surface tension. Certainly the question simply asked for a comparative method of detecting the surface tension difference between water and petrol, but the best method of doing this is still via one of the standard methods of surface tension measurements. As already indicated, very few students followed this line and full credit could be obtained by using the appealing but less satisfactory option of looking at contact angles, which inevitably involves a third surface tension – that of the liquid-solid interface.

Question 5: – 11 marks

a 1 i $\frac{[H_2][I_2]^*}{[HI]^2}$

1 ii $3.10 \times 10^3 \text{ M}^*$

2 iii $[HI]^2 = \frac{[H_2][I_2]}{K} = \frac{(3.10 \times 10^{-5})^2}{6.25 \times 10^{-5}} = 1.538 \times 10^{-2}; [HI] = 3.92 \times 10^{-4} \text{ M}^*$

2 iv $n(HI) = 2 \times (3.92 \times 10^{-4}) + (2^* \times 3.10 \times 10^{-3}) = 9.08 \times 10^{-4} \text{ mol}$

b 3 $p = \frac{nRT}{V} = \frac{8.20 \times 10^{-2} \times 8.31 \times 500}{0.750 \times 10^{-3}} = 454 \text{ 280 Pa} = 454 \text{ kPa}^*$

(one * is for correct substitutions into the ideal gas equation, the final * is essentially for getting all the units right)

c 2 None*, since there is no change in the number of mole present*.

Comment: The most difficult question on the paper. Although the principles of equilibrium as referred to in several places in the study structure, many students do not seem to have developed any overview of the concepts of equilibrium. In particular, the ability to undertake quantitative manipulation of the equations is a rare skill. There is perhaps a need to concentrate more on linking the concepts to the principles of stoichiometry.

Question 6: 9 marks

a 1 large surface area for chemical reaction.

b 2 i Stage 1: decrease* (this is the most probable response – however, since this is a kinetically-controlled reaction whose rate will increase with increasing temperature, raising the temperature will undoubtedly increase its rate and there is an argument that 'increase' is a defensible response. Both were accepted).

Stage 2: decrease* (note that no explanation is required here – a simple statement that clearly implies that the yields of both reactions will decrease will suffice for 2 marks).

2 ii Stage 1: A temperature of around 900°C (the actual number is not required) is needed to make the NH_3 plus O_2 reaction to give NO proceed at a sufficiently rapid rate on the catalyst surface* (relative to other reactions that might occur).

Stage 2: The reaction of NO with O_2 to give NO_2 goes faster as the temperature is lowered. Thus it proceeds both faster and more completely at low temperatures*. (This reaction goes essentially to completion at room temperature – at very high temperatures equilibrium considerations would prevent it from going to completion).

c 1 $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})^*$

d 1 it is recycled back into the 'further oxidation' chamber*

e 1 i NO_2^*

1 ii NO_2^*

(Note that if ' NO_2 ' is given in both places but an incorrect redox half-equation is provided, students were not penalised).

Comment: In many ways a disappointing response to a question that was very clearly based on the mainstream of the study structure. Marks were awarded easily here in that, having indicated NO_2 , as a response to part e, very many students gave irrelevant half-reactions, but were not (of course, penalised for so doing).

General comment: Obviously students still do not read and answer the question. Consistent practice and correction may help, but it is a perennial problem. Students must take care with indication of the state (s, l, or g) in chemical equations as a careless mistake can be very costly. Significant figures too must be constantly addressed.