1996 VCE CHEMISTRY CAT 1

"CHEMISTRY IN A PRACTICAL CONTEXT"

DETAILED SUGGESTED SOLUTIONS

CHEMISTRY ASSOCIATES
P.O. BOX 2227
KEW, VIC., 3101
AUSTRALIA
TEL:(03) 9817 5374 FAX: (03) 9817 4334

email: chemas@vicnet.net.au

Internet: http://www.vicnet.net.au/~chemas/education.htm

A copy of the 1996 Chemistry Cat 1 Examination paper for which these solutions are provided may be obtained from The Victorian Board of Studies. Click here.

http://www.bos.vic.edu.au/

Section A

Question 1 ANS B
From the graph, an absorbance of 0.10 shows a concentration of 2.5 mg L-1. Since the volume of the sample is 100 mL, the mass of iron in the sample = 2.5 x 0.1 = 0.25 mg.

Question 2 ANS C
When more NO gas is added to this system at equilibrium, the reverse reaction is favoured and the amount of NO_2 gas decreases while the amount of N_2O_3 gas increases. There is no change in the value of the equilibrium constant provided the temperature remains constant.

Question 3 ANS B
This ionisation is an equilibrium system. When more water is added, the forward reaction is favoured and more $H_3O^+(aq)$ is produced through the ionisation of more $CH_3COOH(aq)$. Hence, the percentage ionisation increases and the $[H_3O^+(aq)]$ increases. Hence, the pH decreases.

Question 4 ANS C
A conjugate acid-base pair contains two species which differ in formula by **one** H^+ ion.
Hence, H_3O^+/OH^- is **not** a conjugate acid-base pair.

Question 5 ANS D
There is 400 mg of $Mg(OH)_2$ in 10.0 mL. Hence, there is 400 x 10^{-3} x 100 g in 1 L.
Hence, n(Mg) = n($Mg(OH)_2$) = 400 x 10^{-3} x 100/58.3 = 0.686 = 6.9 x 10^{-1}.

Question 6 ANS C
$HNO_3(aq)$ and NaOH(aq) react according to the equation:
$HNO_3(aq) + NaOH(aq) = NaNO_3(aq) + H_2O(l)$
Since the volumes and concentrations of HNO_3 and NaOH are equal, the number of mole of HNO_3 is equal to the number of mole of NaOH. Hence, an exact react takes place. $NaNO_3(aq)$ forms a neutral solution. Hence, the pH of the solution will be closest to 7.

Question 7 ANS A
The waxy substance on the legs of the insects is non-polar. As a result, it will not be attracted to the water. It is hydrophobic (water-hating).

Question 8 ANS B
The liquid will rise to a maximum height in the capillary when the liquid is attracted to the material of the capillary (wets the capillary), has a **high** surface tension (like water) and the diameter of the capillary is **small**(a smaller mass of water is drawn up the capillary).

Question 9 ANS B
Mercury does not wet the glass because the attraction between mercury atoms is much greater than the attraction between mercury atoms and glass. A convex meniscus is formed by mercury in the capillary tube (a capillary depression is observed). Since the contact angle is measured through the liquid, the contact angle is greater than 90^o.

Question 10 ANS C
Since formamide wets the glass like water, it will behave in a similar fashion to water. Hence, a capillary rise will be observed and the contact angle will be less than 90^o.

Question 11 ANS D
The cationic detergent (positively charged) is the one that contains the carbon chain linked to a negatively charged ion. (Br^-). It is $CH_3(CH_2)_{10}N(CH_3)_3Br$
The anionic detergent (negatively charged) is the one that contains the carbon chain linked to a positively charged ion. (Na^+). It is $CH_3(CH_2)_{10}SO_3Na$.

Question 12 ANS D
In the industrial preparation of ethanol, the saturated alkane , propane (C_3H_8), is obtained from crude oil by fractional distillation.

Question 13 ANS A
In the industrial preparation of ethanol, the unsaturated alkene ,ethene (C_2H_4), is obtained from propane by catalytic cracking according to the equation such as : $C_3H_8(g) = C_2H_4(g) + CH_4(g)$.

Question 14 ANS C
In the industrial preparation of ethanol, the ethanol is obtained from ethene by the addition of water (hydrogenation) according to the equation: $C_2H_4(g) + H_2O(g) = C_2H_5OH(aq)$.

Question 15 ANS D
The formulas of ethene and propane are, respectively, C_2H_4 and C_3H_8.

Question 16 ANS B
According to the balanced equation, $Zn(s) + 2HCl(aq) = ZnCl_2(aq) + H_2(g)$,
$n(H_2)$ produced = n(Zn) used up = 6.54 /65.4 = 0.1 mol.
Hence, the volume in litres of hydrogen gas produced at 25^oC and 1.00 atm pressure
= 0.1 x 24.4 = 2.44 L. (Note that the volume occupied by 1 mol of gas at 25^oC and 1.00 atm pressure is not given in the data sheet. However, B is the only reasonable answer)

Question 17 ANS C
From the balanced equation, $Zn(s) + 2HCl(aq) = ZnCl_2(aq) + H_2(g)$, $n(Zn^{2+})$ produced = n(Zn) used up = 6.54 /65.4 = 0.1 mol. Hence, $[Zn^{2+}(aq)] = 0.1/0.25 = 0.40$ M.

Question 18 ANS C
The reaction, $Zn(s) + 2HCl(aq) = ZnCl_2(aq) + H_2(g)$, is best described as a redox reaction since zinc is oxidised from 0 to +2 and hydrogen is reduced from +1 to 0.

SECTION B Question 1 (1 + 2 + 1 = 4 marks)

a. The balanced ionic half-equation for the reduction of molecular bromine (Br_2) to bromide ions (Br^-) in aqueous solution is $Br_2(aq) + 2e^- = 2Br^-(aq)$

b. The balanced ionic half-equation for the oxidation of hydrogen sulfide (H_2S) to the sulfate ion (SO_4^{2-}) in acid solution is $H_2S(aq) + 4H_2O(l) = SO_4^{2-}(aq) + 10H^+(aq) + 8e^-$

c. The balanced equation of the oxidation of hydrogen sulfide to sulfate by molecular bromine is $4Br_2(aq) + H_2S(aq) + 4H_2O(l) = SO_4^{2-}(aq) + 10H^+(aq) + 8Br^-(aq)$

Question 2 (2 + 2 + 2 + 2 +3 = 11 marks)

a. Three out of the following four errors could be used

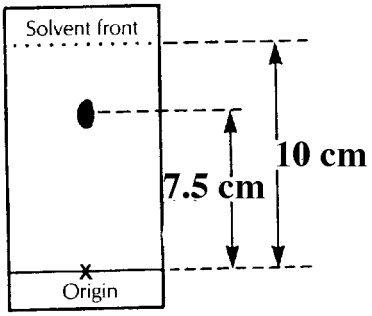
(1) The Felt tip pen 'ink' may contain colourings that may interfere with the proposed study (use pencil, or a scratch on paper).

(2) A spot 10 mm in diameter would be unnecessarily large
(place small spot covering small area).

(3) The spot must not be covered by solvent (spot must be clear of the solvent surface).

(4) 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).

b. The R_f value is calculated as the ratio
R_f = (distance moved from origin by spot /distance moved from origin by solvent). This is shown in the diagram below for an R_f value of 7.5/10 = 0.75



c. The features common to all types of chromatography are:

(1) the mixture to be separated in a mobile phase (solvent, gas)

(2) stationary phase that differentially adsorbs the components of the mixture in the mobile phase

(3) rate of motion of components of mixture depends on degree of adsorption, hence separation.

Question 3 (1 + 2 + 2 + 1 + 3 + 2 + 2 = 13 marks)

a. The balanced equation is: $Fe_2O_3(s) + 3CO(g) = 2Fe(l) + 3CO_2(g)$

or

$2Fe_2O_3(s) + 3C(s) = 4Fe(l) + 3CO_2(g)$

b. $O_2(g)$ generates the reductant CO(g) by reacting with carbon according to the equation:

$2C(s) + O_2(g) = 2CO(g)$

c. The balanced equations are: $S(s) + O_2(g) = SO_2(g)$ and $2SO_2(g) + O_2(g) = 2SO_3(g)$

d. The balanced molecular equation is: $Fe(s) + H_2SO_4(aq) = FeSO_4(aq) + H_2(g)$

The balanced ionic equation is: $Fe(s) + H_2SO_4(aq) = Fe^{2+}(aq) + SO_4^{2-}(aq) + H_2(g)$

e. The oxidation numbers in sulfuric acid are: H =+l; S=+6; O=-2

f. **i.** The environmental hazards associated with the production of iron are: dust, noise, CO_2, thermal pollution.

ii. The main environmental hazard associated with the production of sulfuric acid is the release of sulfur dioxide, SO_2

g. **i.** Important uses for iron are: construction material, production of steel.

ii. Important uses for sulfuric acid are: **synthesis** of fertilisers, (NOT direct use as a fertiliser!!) car battery acid.

Question 4 (1 + 1 + 1 + 2 + 1 = 6 marks)

a. $K_c = \dfrac{[NH_3]_e^2}{[N_2]_e[H_2]_e^3}$ where K_c is the equilibrium constant and *e* indicates that the concentrations are measured at equilibrium

b. From the graph at 300 atmospheres and 500ºC, the percentage yield of ammonia is 24 ±1%

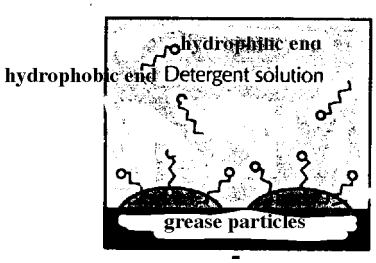
c. Le Chatelier's Principle states that: "A system at equilibrium will respond to any change in its conditions that can affect the position of equilibrium, so as to minimise the effects of that change."

d. The % conversion at equilibrium decreases with increasing temperature. Hence, the reaction for the production of ammonia must be exothermic. The equilibrium constant decreases as the temperature increases.

e. Even though the yield is greater at temperatures less than 400°C, the reaction is too slow under these conditions to be economically viable.

Question 5 (3 + 2 + 2 + 1 = 8 marks)

a. Show flat plate surface with smears of grease adhering; show hydrophilic and hydrophobic parts of detergent molecule; show hydrophobic part stuck in grease and hydrophilic part in the water. This is illustrated below.



b. **i**. The water dipole (O^-, H^+) interacts by electrical attraction with the ionic or polar part of the detergent molecule (the hydrophilic end)

ii. There are dispersion forces between hydrophobic part of detergent and the hydrophobic grease.

c. Micelle-like structures are formed with blob of grease made soluble by the detergent with the the hydrophobic ends of the detergent molecules in the grease and the hydrophilic ends of the detergent molecules attracted to the water molecules.

d. The hot water turns the grease from a solid into a liquid, thereby making it easier to disperse in the solution.

Question 6 (2 + 1 + 1 + 1 + 2 + 1 = 8 marks)

a. $n(Cr_2O_7^{2-}) = (8.20/1000) \times 0.0500 = 4.10 \times 10^{-4}$ mole **ANS**

b. From the balanced equation: $n(CH_3CH_2OH) = n(Cr_2O_7^{2-}) \times (3/2)$
$= 4.10 \times 10^{-4} \times (3/2) = 6.15 \times 10^{-4}$ mole **ANS**

c. The alcohol concentration in the aliquot = $n/V = 6.15 \times 10^{-4} \times (1000/25) = 0.0246$ M **ANS**

d. The concentration of the alcohol in the original sample of beer $= 0.0246 \times (500/20)$
$= 0.615$ M **ANS**

e. The mass of alcohol in a standard 200 mL glass of the beer $= 0.615 \times 46 \times (200/1000)$
$= 5.66$ g **ANS**

f. Safety precautions that should be taken during this analysis include the use of safety glasses, laboratory coat, gloves and pipette filler.

END OF SUGGESTED SOLUTIONS

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