VCE CHEMISTRY
CAT 1 1994

"CHEMISTRY IN A PRACTICAL CONTEXT"

DETAILED SUGGESTED SOLUTIONS

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Section A

Question 1

Item 1 ANS D
Since component X has moved further than component Y, Y is more strongly adsorbed by the paper (the stationary phase) than X.
The R_f value = $\frac{\text{distance moved from the origin by the component}}{\text{distance moved from origin by solvent}}$.
This value is smaller for Y than for X.

Item 2 ANS A
A water in oil emulsion has droplets of water dispersed and suspended throughout the oil. Hence, the feel will be greasy since the fingers will come into direct contact with the oil. The oil base will not mix easily with water and the electrical conductivity will be lower than an oil in water emulsion. A water in oil emulsion requires an oil soluble dye to colour it.

Item 3 ANS C
This detergent molecule carries a positive charge. A positively charged ion is called a cation. Hence, this is a cationic detergent.

Item 4 ANS D

Number of mole of vitamin C $= \frac{\text{mass in g}}{\text{relative molecular mass}}$

$= \frac{80 \times 10^{-3}}{176} = 0.00045$ mol.

Item 5 ANS B

Concentration of vitamin C = $\frac{\text{number of mole}}{\text{volume in litres}} = \frac{0.00045}{0.2} = 0.0023$ mol L^{-1}.

Note that the concentration remains the same at different volumes assuming the orange juice is a homogeneous solution.

Item 6 ANS C
The number of mole carbon dioxide produced = the number of mole of cream of tartar since the baking soda is present in excess and, therefore, the cream of tartar will react completely. Hence,
$n(CO_2)$ produced = $\frac{\text{mass}}{\text{relative molecular mass}} = \frac{0.50}{188.1}$.
Therefore, $n(CO_2)$ produced at SLC (standard laboratory conditions)
$= \frac{0.50}{188.1} \times 24.5 = 0.065$ L.

Section A

Question 1

Item 7 ANS C

$pH = -\log_{10}[H_3O^+]$.

The table below shows the hydrogen ion concentrations and the pH for each of the substances listed.

substance	concentration	hydrogen ion concentration	pH
pure water	55.5 M	10^{-7} M	7
HCl	0.001 M	10^{-3} M	3
H_2SO4	0.001 M	2×10^{-3} M	2.7
NaOH	0.001 M	$\frac{10^{-14}}{10^{-3}} = 10^{-11}$ M	11

Hence, the order of increasing pH is $H_2SO4 < HCl < H_2O < NaOH$.

Item 8 ANS A

$pH = -\log_{10}[H_3O^+]$. Hence, when pH = 5, $[H_3O^+] = 10^{-5}$ M.

Hence, $[OH^-] = \frac{10^{-14}}{10^{-5}} = 10^{-9}$ M

Item 9 ANS B

The balanced equation for this reaction is:

$NaOH(aq) + HNO_3(aq) = NaNO_3(aq) + H_2O(l)$.

Notice that 1 mole of NaOH reacts exactly with 1 mole of HNO_3.

Therefore, in this reaction, the number of mole of HNO_3 in excess

$= (0.2 \times 0.202) - (0.2 \times 0.200) = 0.0404 - 0.04 = 0.0004$ mol.

Hence, number of mole of H_3O^+ in excess = 0.0004 mol.

Hence, $[H_3O^+]$ in the resultant solution $= \frac{0.0004}{0.4} = 0.001$ M $= 10^{-3}$ M.

Hence, pH = 3.

Item 10 ANS C

The pipette and the burette must always be rinsed with the solution that is to be used in each of them. They must not be rinsed with water since this would change the concentration of the solution in the pipette or the burette in a way that could not be measured. On the other hand, the conical flask should be rinsed with pure water. Pure water remaining in the conical flask will not change the equivalence point of the reaction.

Section A

Question 1

Item 11 ANS D
Before delivery, the bottom of the meniscus curve must just touch the line on the pipette (C or D). After delivery, a small amount must remain in the tip of the pipette. (D).

Item 12 ANS A
Since both students used the same volume of diluted vinegar, they each had the same number of mole of acetic acid in the conical flasks. Hence, they would each use the same number of mole of NaOH in the titration and should obtain the same value for the concentration of acetic acid.

Item 13 ANS A
Acid is always diluted by adding acid to water. "Do what you oughta, add acid to water!" The dilution of concentrated sulfuric acid generates a large amount of heat. Hence, cold water is used in preference to hot water to remove some of this heat. In fact, it is best to have the beaker sitting on a bed of ice to keep the temperature of solution low.

Item 14 ANS B
At point X on the graph, the volume of hydrogen gas produced has reached a constant value. Since the amount of hydrochloric acid is constant, the magnesium must now be in excess.

Item 15 ANS C
In hydrogen peroxide, the oxidation number of oxygen is -1. In oxygen gas, the oxidation number of oxygen is 0. Hence, the oxygen has been oxidised and the hydrogen peroxide is acting as a reductant. Notice also that the oxidation number of manganese (Mn) has decreased from +7 to +2. The manganese in the permanganate ion has been reduced by the oxygen in the hydrogen peroxide.

Item 16 ANS C
The concentration fraction has the value: $\frac{[SO_3]}{[SO_2]^2\,[O_2]}$. At the instant oxygen is added to the equilibrium mixture, the value of the concentration fraction will be lower than the initial (equilibrium) concentration fraction.

Item 17 ANS D
The equilibrium constant increases as the temperature increases. Hence, this reaction is endothermic. (ΔH is positive).

Section A

Question 1

Item 18 ANS D
'Cracking' as the name suggests involves breaking down long chained hydrocarbons into shorter ones. The separation of molecules occurs through the process of distillation.

Item 19 ANS A
Polyvinyl chloride is formed by addition polymerisation from the monomer CH2CHCl which is vinyl chloride or monochloroethene.

Item 20 ANS B
Enzymes, which are proteins, are more specific in their actions than inorganic catalysts such as platinum. They also produce faster reaction rates and operate under less severe conditions than inorganic catalysts.

Section B

Question 2

a. $n(BaSO_4) = \frac{7.66}{(137.4+32.1+64)} = \frac{7.66}{233.5} = 0.033$ mol **ANS**

b. $n(SO_4^{2-}) = n(BaSO4) = 0.033$ mol **ANS**

c. $m(SO_4^{2-})$ in Greenfude = 0.033 x (32.1 + 64) = 0.033 x 96.1 = 3.15 g **ANS**

d. % SO_4^{2-} in Greenfude = $\frac{3.15}{40.0}$ x 100 = 7.88% **ANS**

e. If the precipitate of $BaSO_4$ were not completely dry, the percentage of sulfate calculated would be greater than the actual percentage.

f. The addition of more barium chloride would have no effect on the calculated percentage of sulfate since all of the sulfate has already been precipitated.

Section B

Question 3

a. **i.** $C(s) + O_2(g) = CO_2(g)$ and $CO_2(g) + C(s) = 2CO(g)$

ii. $Fe_2O_3(s) + 3CO(g) = 2Fe(l) + 3CO_2(g)$

iii. $CaCO_3(s) = CaO(s) + CO_2(g)$ and $CaO(s) + SiO_2(s) = CaSiO_3(l)$

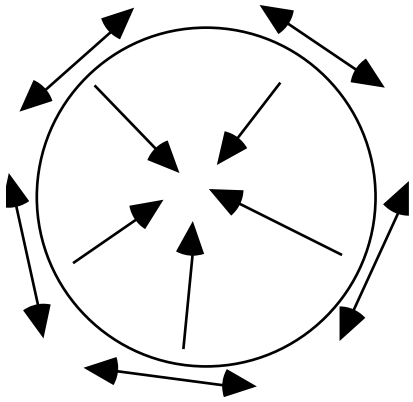
b. The source of energy is the exothermic reactions occurring in the blast furnace.

c. Because the molten slag floats on top of the molten iron, the iron and slag can be separated easily and the iron is reasonably pure.

d. When all operations are placed on the one site, transport costs are greatly reduced.

Question 4

a. At the surface of a liquid the forces of attraction are along the surface and into the body of the liquid. This creates an overall downwards force on the surface particles. This surface tension tries to reduce the liquid's surface area (and hence, its total surface energy) to a minimum. This is shown in the diagram below.



b. Method: On the same surface add 10 drops of water to the one spot. Observe the size of the drop produced and the angle formed with the surface. Repeat this process for petrol.

Expected observations: The petrol would spread out more across the surface and form a smaller contact angle with the surface.

Explanation of results: The attraction between water molecules is greater than the attraction between petrol molecules. Water has a greater surface energy than petrol.

Section B

Question 4 (continued)

c. As the temperature increases, the molecules of water vibrate more rapidly and move further apart. Hence, the surface tension decreases.

d. **i.** The steel needle is coated with grease from the hands of the students. This creates a hydrophobic surface and repels the water molecules. The needle 'floats'.

ii. The detergent dissolves the grease layer and the water is able to flow over the surface of the needle. The needle sinks.

Question 5

a. **i.** The equilibrium expression is $K_c = \frac{[H_2(g)]\,[I_2(g)]}{[HI(g)]^2}$ where the concentrations of H_2, I_2 and HI are the equilibrium concentrations.

ii. In this equilibrium mixture, at 500 K,
$[H_2(g)] = [I_2(g)] = 3.10 \times 10^{-5}$ mol L^{-1} since in the dissociation of HI, equal quantities of H_2 and I_2 are produced.

iii. From the equilibrium expression, $6.25 \times 10^{-3} = \frac{(3.10 \times 10^{-5})^2}{[HI(g)]^2}$.

Hence, $[HI(g)]^2 = \frac{(3.10 \times 10^{-5})^2}{6.25 \times 10^{-3}}$.

Therefore, $[HI(g)] = 3.92 \times 10^{-4}$ mol L^{-1} **ANS**

iv. n(HI) originally in the 2.0 L vessel

= n(HI) at equilibrium + n(HI) which has dissociated
= $(3.92 \times 10^{-4} \times 2)$ + 2 x n(I_2) formed
= $(3.92 \times 10^{-4} \times 2) + (2 \times 2 \times 3.10 \times 10^{-5})$
= $(7.84 \times 10^{-4}) + (1.24 \times 10^{-4})$
= 9.08×10^{-4} mol **ANS**

Section B

Question 5 (continued)

b. $P(HCl) = \frac{nRT}{V}$

$$= \frac{8.20 \times 10^{-2} \times 8.31 \times 500}{750 \times 10^{-6}} \text{ Pa}$$

$$= \frac{8.20 \times 10^{-2} \times 8.31 \times 500}{750 \times 10^{-6} \times 1000} \text{ kPa}$$

$$= 454.28$$

$$= 454 \text{ kPa} \quad \textbf{ANS}$$

c. When two mole of HI dissociates, two mole of gas is produced. Hence, the number of mole of gas does not change. Hence, the pressure stays the same at constant temperature.

Question 6

a. For reaction to occur, the ammonia and the air must come into contact with each other in the presence of the catalyst. Gauze, powder and sponge have a much larger surface area than a solid lump. The larger the surface area, the better the contact between the reactants.

b. **i.** For an exothermic reaction, the yield decreases with increasing temperature.

ii. In stage 1, the short contact time and the relatively high temperature are used to ensure that the desired reaction occurs more rapidly than other possible reactions. In stage 2, both the rate of reaction and the yield of the reaction increase as the temperature is lowered. Hence, a much lower temperature is used here than in stage 1.

c. $2NO(g) + O_2(g) = 2NO_2(g)$

d. The NO(g) that is produced in stage 3 according to the equation $NO_2(g) + H_2O(l) = 2HNO_3(aq) + NO(g)$, is recycled to stage 2.

e. **i.** N in NO_2 (+4) is reduced to N in NO (+2)

ii. N in NO_2 (+4) is oxidised to N in HNO_3 (+5)

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