Trial Examination 2006

VCE Chemistry Unit 3

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

1	A	**B**	C	D
2	**A**	B	C	D
3	A	B	C	**D**
4	A	B	C	**D**
5	**A**	B	C	D
6	A	B	C	**D**
7	A	**B**	C	D
8	A	B	**C**	D
9	A	B	**C**	D
10	A	B	C	**D**

11	**A**	B	C	D
12	A	B	**C**	D
13	A	B	C	**D**
14	**A**	B	C	D
15	A	B	**C**	D
16	A	B	**C**	D
17	A	**B**	C	D
18	A	**B**	C	D
19	A	**B**	C	D
20	**A**	B	C	D

Question 1 B

Type of solvent, rate of flow and temperature all influence retention times. Concentration influences the peak area, not the retention time.

Question 2 A

Reactions I and II involve oxidation of sulfur. III does not ∴ not **B**.

Reaction III occurs at room temperature. Reaction II occurs at approximately 450°C. Reaction I occurs at high temperatures ∴ not **C**.

Elevated pressures are not used ∴ not **D**.

Question 3 D

Determining levels is quantitative ∴ not **A** or **B**.

Accuracy at μg level is required ∴ not **C**.

Question 4 D

$n(H^+) = n(HCl) = c \times V = 0.00100 \times 20.00 \times 10^{-3} = 2.00 \times 10^{-5}$ mol

$n(OH^-) = 2 \times n(Ba(OH)_2) = 2 \times c \times V = 2 \times 0.00100 \times 20.00 \times 10^{-3} = 4.00 \times 10^{-5}$ mol

∴ OH is in excess by 2.00×10^{-5} mol.

$$[OH^-] = \frac{n}{V} = \frac{2.00 \times 10^{-5}}{40.00 \times 10^{-3}} = 5.00 \times 10^{-4} \text{ M}$$

$$[H_3O^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{5.00 \times 10^{-4}} = 2.00 \times 10^{-11} \text{ M}$$

$$pH = -\log[H_3O^+] = -\log(2.00 \times 10^{-11}) = 10.7$$

Question 5 A

With an equal number of moles of products and reactants, this reaction does not respond to a change in pressure.

Question 6 D

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{1.0 \times 1.0}{1.0} = 1.0$$

The equilibrium constant, K, is 1.70.

∴ $K_c < K$, hence the reaction moves to the right to reach equilibrium.

∴ temperature decreases (endothermic reaction) and PCl_5 mass decreases.

Question 7 B

The reaction is rapid (∴ not **A**), extensive (∴ not **D**), and does not require a catalyst (∴ not **C**). The highly exothermic nature means that any sulfuric acid produced forms a 'fog' and is difficult to collect.

Question 8 C

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

$$n(HCl) = c \times V = 0.020 \times 100.0 \times 10^{-3} = 0.0020 \text{ mol}$$

$$n(CaCO_3) = \frac{1}{2} \times n(HCl) = \frac{1}{2} \times 0.0020 = 0.0010 \text{ mol}$$

$$m(CaCO_3) = n \times M = 0.0010 \times 100.1 = 0.10 \text{ g}$$

$$\%\ CaCO_3 = \frac{m(CaCO_3)}{m(\text{sample})} \times \frac{100}{1} = \frac{0.10}{0.16} \times \frac{100}{1} = 63\%$$

Question 9 C

Assuming the Fe^{2+} ion, we have CrO_2^-

$\therefore$ ((oxidation number of Cr) – (2 × 2) = –1)

$\therefore$ oxidation number of Cr = +3

Question 10 D

$$n(CO_2) = \frac{V}{V_m} = \frac{14.6}{24.5} = 0.596 \text{ mol}$$

$$n(C) = n(CO_2)$$

$$m(C) = n \times M = 0.596 \times 12.0 = 7.15 \text{ g}$$

$$\therefore\ m(H) = 8.75 - 7.15 = 1.60 \text{ g}$$

$$C{:}H = \frac{7.15}{12.0} : \frac{1.60}{1.0} = 0.596 : 1.60 = 1 : 2.68 = 3 : 8$$

Question 11 A

The reaction has a 1:1 stoichiometry. At the equivalence point of the titration the species present will be the conjugate acid of the weak base and the conjugate base of the strong acid. These species will be, respectively, a weak acid and an extremely weak base. The presence of the weak acid means that the solution will be acidic at the equivalence point.

Question 12 C

In AAS the sample is vaporised $\therefore$ not **A**.

In gravimetric analysis the sample reacts and a precipitate forms $\therefore$ not **B**.

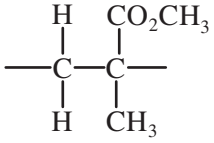
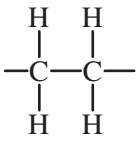
In acid-base volumetric analysis the sample reacts $\therefore$ not **D**.

In UV-visible spectrometry the sample remains unreacted in solution.

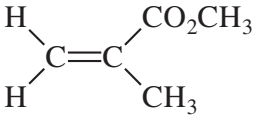
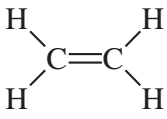
Question 13 D

During the formation of each of the products listed in **A**, **B** and **C**, a molecule of HCl also forms.

Question 14 **A**

 and  are the repeating sections.

The monomers are therefore

 and 

Question 15 **C**

$$n(AlCl_3) = c \times V = 0.10 \times 20.00 \times 10^{-3} = 0.0020 \text{ mol}$$

$$n(PbCl_2) = \frac{3}{2} \times n(AlCl_3)$$

$$m(PbCl_2) = n \times M = \frac{3}{2} \times 0.0020 \times 278.2 = 0.835 \text{ g}$$

$$\% \text{ yield} = \frac{m(PbCl_2)_{obtained}}{m(PbCl_2)_{expected}} \times \frac{100}{1} = \frac{0.56}{0.835} \times \frac{100}{1} = 67\%$$

Question 16 **C**

There is no change in the oxidation number of the sulfur in the reaction. Therefore it is not a redox reaction. ∴ not **A**, **B** or **D**. The relevant acid-base conjugate pairs are

$$H_2SO_4 \rightarrow HSO_4^- \rightarrow SO_4^{2-}$$

$$O^{2-} \rightarrow OH^- \rightarrow H_2O$$

Question 17 **B**

Decreased temperature will mean a decreased reaction rate in experiment 2 ∴ **A** or **B**.

The reaction is endothermic, hence lowering the temperature will reduce the yield ∴ **B**.

Question 18 **B**

Z is the lowest point in the column, therefore it is the highest boiling temperature collection point.

∴ mainly alkane P.

Question 19 **B**

Lowering pressure lowers the boiling temperatures ∴ **A** or **B**.

At *Y*, alkane P (normally collected at the higher boiling point *Z*) will be collected.

Question 20 **A**

The presence of chloride ion in the salt water moves the position of equilibrium to the left. Hence there is less hydronium ion, and so pH increases. Sodium ions do not react with water (∴ not **D**).

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $K = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$ 1 mark

b.

	N_2	$3H_2$	$2NH_3$
n_i	0.020	> 0	0
change	$-\dfrac{0.0050}{2}$		+0.0050
n_{eq}	0.0175		0.0050
c_{eq}	$\dfrac{0.0175}{0.50}$		$\dfrac{0.0050}{0.50}$

2 marks

$$[H_2]^3 = \frac{[NH_3]^2}{[N_2] \times K} = \frac{\left(\frac{0.0050}{0.50}\right)^2}{\left(\frac{0.0175}{0.50}\right) \times 0.00659}$$

$\therefore [H_2]^3 = 0.4336$ 1 mark

$\therefore [H_2] = 0.76$ M 1 mark

c. $K_{required} = \dfrac{1}{K^2} = \dfrac{1}{(0.00659)^2} = 2.30 \times 10^4$ 1 mark

Total 6 marks

Question 2

a. $n(MnO_4^-) = c \times V = 0.0198 \times 0.01971 = 0.0003903 = 3.90 \times 10^{-4}$ mol 1 mark

b. $n(Fe^{2+}) = 5 \times n(MnO_4^-) = 5 \times 0.0003903$ (in the 25.00 mL aliquot) 1 mark

$n(Fe^{2+}) = \dfrac{100.0}{25.00} \times 5 \times 0.0003903 = 0.007806 = 7.81 \times 10^{-3}$ (in the 100.0 mL flask) 1 mark

c. $m(Fe) = m \times M = 0.007806 \times 55.8 = 0.4356 = 0.436$ g 1 mark

$\%\ Fe = \dfrac{m(Fe)}{m(sample)} \times \dfrac{100}{1} = \dfrac{0.4356}{0.440} \times \dfrac{100}{1} = 99.0\ \%$ 1 mark

d. Gravimetric analysis. (*e.g. Precipitation of iron(II) hydroxide and subsequent conversion to iron(III) oxide.*) 1 mark

e. Atomic absorption spectrometry. (*Sample would need to be diluted.*) 1 mark

Total 7 marks

Question 3

a. **i.** $CH_3CH_2CH_2CH_2OH$ 1 mark

ii. CH_3CH_2COOH 1 mark

iii. $CH_3CH_2COOCH_2CH_2CH_2CH_3$ 1 mark

b. **i.** KOH 0.5 marks

ii. $K_2Cr_2O_7$ or $KMnO_4$ 0.5 marks

c. **i.** KCl 0.5 marks

ii. H_2O 0.5 marks

d. Either

$$CH_3CH_2CHCH_2 \xrightarrow{H_2O/H^+} CH_3CH_2CH_2CH_2OH$$

or

$$CH_3CH_2CHCH_2 \xrightarrow{HCl/catalyst} CH_3CH_2CH_2CH_2Cl$$ 1 mark

Total 6 marks

Question 4

a. 5 M = 5 mol in 1 L of solution

$\therefore\ 5 \times M(CuSO_4)$ g in 1 L

$\therefore\ 5 \times 159.6 \times 0.1$ g in 100 mL

$\therefore$ 79.8% m/V 1 mark

Absorbance readings are valid for concentrations from 2.0 to 10.0% m/V. 1 mark

$\therefore$ a 10-fold dilution is required to produce an approximately 8.0% m/V solution. 1 mark

b. It has been assumed that any impurities do not absorb light of wavelength 610 nm. 1 mark

c. Solutions strongly absorb their complementary colour. 1 mark

Blue solutions absorb red light, so it is likely that 610 nm is red. 1 mark

Total 6 marks

Question 5

a. hydrolysis, addition 1 mark

b.

Characteristic	Increased by the catalyst	Decreased by the catalyst	Unchanged by the catalyst
ΔH value			✓
Equilibrium yield of ethanol			✓
Rate of reverse reaction $C_2H_5OH_{(aq)} \rightleftharpoons C_2H_{4(g)} + H_2O_{(l)}$	✓		

3 marks

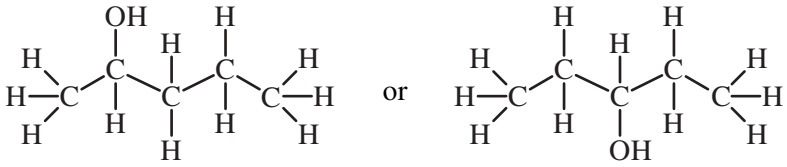
c. $m(CH_3CH_2OH) = \rho \times V = 0.785 \times 5.00 \times 10^3 = 3.925 \times 10^3$ g — 0.5 marks

$n(CH_3CH_2OH) = \dfrac{m}{M} = \dfrac{3.925 \times 10^3}{46.0} = 85.3$ mol — 1 mark

$n(CH_2CH_2) = n(CH_3CH_2OH)$ — 0.5 marks

$m(CH_2CH_2) = n \times M = 85.3 \times 28.0 = 2.39 \times 10^3$ g — 1 mark

d. **i.**



1 mark

ii. 2-pentanol or 3-pentanol — 1 mark

Total 9 marks

Question 6

a. **i.** $H_2O_{2(l)} \rightleftharpoons O_{2(g)} + 2H^+_{(aq)} + 2e^-$ — 1 mark

ii. $H_2O_{2(l)} + 2H^+_{(aq)} + 2e^- \rightleftharpoons 2H_2O_{(l)}$ — 1 mark

iii. The reaction rate is slow, but catalysed by light. — 1 mark

Dark bottles exclude light, so the reaction proceeds very slowly. — 1 mark

b. **i.** $K_a = \dfrac{[HO_2^-][H_3O^+]}{[H_2O_2]}$ — 1 mark

ii. $[H_3O^+] = [HO_2^-] = 10^{-pH} = 10^{-6.0}$ — 1 mark

$[H_2O_2] = \dfrac{(10^{-6.0})^2}{K_a} = \dfrac{(10^{-6.0})^2}{2.27 \times 10^{-12}} = 0.44$ M — 1 mark

c. **i.** acid — 0.5 marks

ii. $[OH^-] = [H_3O^+] = \sqrt{1.0 \times 10^{-13}} = 10^{-6.5}$

$pH = -\log[H_3O^+] = -\log 10^{-6.5} = 6.5$

1 mark

iii. neutral — 0.5 marks

d. 60 g of H_2O_2 per 1.0 L of solution

$\therefore \dfrac{60}{34}$ mol of H_2O_2 per 1.0 L of solution

$\therefore$ 1.76 mol of H_2O_2 per 1.0 L of solution — 0.5 marks

1.76 mol of H_2O_2 releases 0.882 mol ($1:\dfrac{1}{2}$ mole ratio) of oxygen — 0.5 marks

$V(O_2) = n \times V_m = 0.882 \times 22.4 = 19.9$ L — 0.5 marks

$\therefore$ The concentration of the solution is '20 volume'. — 0.5 marks

Total 11 marks