Neap:

Trial Examination 2007

VCE Chemistry Unit 3

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

Question				
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

The increase in yield with increasing pressure relates to the amounts (in mol) of reactants and products. Increasing pressure moves the equilibrium to the right to reduce the pressure (2 mol of products produces less pressure than 4 mol of reactants). Decreasing yield with increasing temperature relates to the exothermic nature of the reaction. As temperature increases, the equilibrium moves to the left to decrease temperature.

Question 2 D

$[H_3O^+] = 1.71 \times 10^{-7}$ M

$\therefore [OH^-] = 1.71 \times 10^{-7}$ M ($[H_3O^+] = [OH^-]$ in pure water)

$K_W = [H_3O^+][OH^-] = (1.71 \times 10^{-7})^2 = 2.92 \times 10^{-14}$ M^2

Since $[H_3O^+] > 10^{-7}$ M, there are more ions than at 25°C, so **C** is incorrect. Pure water is neutral at all temperatures, since $[H_3O^+] = [OH^-]$, so **A** is incorrect. $[OH^-] = 1.71 \times 10^{-7}$ M, so **B** is incorrect.

Question 3 C

The gas acts as a carrier gas. It does not react with the components of the mixture so an inert/unreactive gas is required (N_2, Ne and Ar are therefore suitable). O_2 is a reactive gas and so is unsuitable.

Question 4 A

For an exothermic reaction, *H* products < *H* reactants, hence **A** or **B** is the answer. A catalyst lowers the activation energy for the reaction, hence **A** is the correct profile.

Question 5 B

The 1.0 M HCl will react at a faster rate (rate α concentration of reactant), hence initial rate and time for completion will differ for the two solutions (hence neither **A** nor **C** is the answer). The Mg completely reacts to produce H_2 gas in each flask, so the mass loss will be the same. As the rate of reaction is different, the rate of production of Mg^{2+} ion in each flask is different (so **D** is not the answer).

Question 6 C

$$K_C = \frac{[Z]^3}{[X]^2[Y]}$$

For I, $K_C = 8$. For II, $K_C = 32$. For III $K_C = 0.125$. For IV, $K_C = 1$.

At equilibrium, $K_C = K = 0.125$.

Therefore, mixture III had reached equilibrium.

Question 7 D

$$K_a = \frac{[CN^-][H_3O^+]}{[HCN]}$$

Let $[H_3O^+] = x$

$\therefore [CN^-] = x$ and $[HCN] = 0.10 - x \cong 0.10$ (since x is very small for a weak acid)

$\therefore K_a = 6.0 \times 10^{-10} = \dfrac{x^2}{0.10}$

$\therefore x^2 = 6.0 \times 10^{-11}$

$\therefore x = 7.75 \times 10^{-6}$

$\therefore \text{pH} = -\log[H_3O^+] = -\log(7.75 \times 10^{-6}) = 5.1$

Question 8 **B**

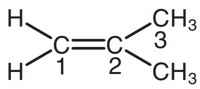
$1C_xH_y + 6O_2 \rightarrow 4CO_2 + \frac{y}{2}H_2O$

$\therefore x = 4$, and $8 + \frac{y}{2} = 12$

$\therefore y = 8$

$\therefore C_4H_8$ an isomer of butene

$\therefore$ 2-methylpropene



Question 9 **C**

$pV = nRT = \frac{m}{M}RT$

$\therefore M = \frac{mRT}{pV} = \frac{2.38 \times 8.31 \times 473}{1.2 \times 101.3 \times 2.4} = 32.1 \text{ g mol}^{-1}$

The gas is therefore O_2 (M = 32 g mol^{-1}).

Question 10 **D**

$[OH^-] = 2 \times [Ca(OH)_2] = 2 \times 1.62 \times 10^{-2} = 3.24 \times 10^{-2}$ M

$[H_3O^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{3.24 \times 10^{-2}} = 3.09 \times 10^{-13}$

$pH = -\log[H_3O^+] = -\log(3.09 \times 10^{-13}) = 12.5$

Question 11 **A**

CH_3COOH is acidic, hence it will have a low pH (**D** is not the answer).
CH_3OH is neutral, and so will have a pH of 7 (**C** is not the answer).

For NaOH, $n(\text{NaOH}) = \frac{m}{M} = \frac{m}{40.0}$ mol

$[OH^-] = [\text{NaOH}] = \frac{n}{V} = \frac{m}{40.0 \times 0.250}$ M

For KOH, $n(\text{KOH}) = \frac{m}{M} = \frac{m}{56.1}$ mol

$[OH^-] = [\text{KOH}] = \frac{m}{56.1 \times 0.250}$ M

The highest pH will have the largest $[OH^-]$, hence NaOH.

Question 12 **B**

Removal of NO will move reaction 1 to the right, using more ammonia and oxygen, hence answer **B**. Removing NO leaves less NO for step 2, and so less NO_2 will be produced (so not answer **A**). Only change in temperature will alter the value of K (so not answer **C**). Reducing the concentration of NO in reaction 2 will decrease reaction rate (so not answer **D**).

Question 13 B

Step 2 is exothermic, so a low temperature favours the forward, energy releasing process (hence **A** or **B**). 3 mol of reactants exert a greater pressure than 2 mol of products, so high pressure favours the forward, pressure reducing process.

Question 14 D

The second equation has been doubled ($\therefore K_2^2$) and added to the first equation, hence, $K = K_1 \times K_2^2$.

Question 15 A

Initially, the type of substance was determined, hence qualitative analysis. The figure of 30 mL comes from a quantitative analysis.

Question 16 C

AAS and AES are used to quantify metal concentrations. Ethylene glycol is an organic molecule which may be analysed by GLC and UV-visible spectroscopy.

Question 17 A

Ethylene glycol is 1,2-dihydroxyethane. An isomer will be 1,1-dihydroxyethane.

Question 18 D

Look for a change in oxidation numbers. In **D**, the oxidation of C in CH_4 is –4, the oxidation of C in CO_2 is +4, hence oxidation has occurred. **A** and **C** are acid–base reactions. **B** is a precipitation reaction.

Question 19 A

Propyl ethanoate has the semi-structural formula $CH_3COOCH_2CH_2CH_3$, and hence the molecular formula $C_5H_{10}O_2$. Hexanoic acid has six carbon atoms and so is not a structural isomer of $C_5H_{10}O_2$. The other esters listed are **B**, $HCOOCH_2CH_2CH_2CH_3$, **C**, $CH_3CH_2COOCH_2CH_3$ and **D**, $CH_3CH_2CH_2COOCH_3$, all isomers of $C_5H_{10}O_2$.

Question 20 C

R_f for I is $\frac{5.9}{8.5} = 0.69$

R_f for II is $\frac{4.1}{5.9} = 0.69$

Hence **C** is the correct answer.

(Common R_f values suggest the same substance. Confirmation by another experiment, such as developing chromatograms in a different solvent, would be needed to say that the two solids ***must*** *be the same.)*

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. The absorbance of the sample over a range of wavelengths is recorded and graphed. 1 mark
The wavelength of maximum absorbance is usually chosen for use in analysis. 1 mark

b. A calibration curve is prepared by measuring the absorbances of a series of standard solutions and graphing absorbance versus concentration. 1 mark
The absorbance of the sample is measured and the concentration found by interpolation on the calibration curve. 1 mark

Total 4 marks

Question 2

a. $MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + CO_2(g) + H_2O(l)$ 1 mark

b. **i.** $n(CO_2) = \frac{V}{V_M} = \frac{115 \times 10^{-3}}{24.5} = 4.69 \times 10^{-3}$ mol 1 mark

ii. $n(MCO_3) = n(CO_2) = 4.69 \times 10^{-3}$ mol 1 mark

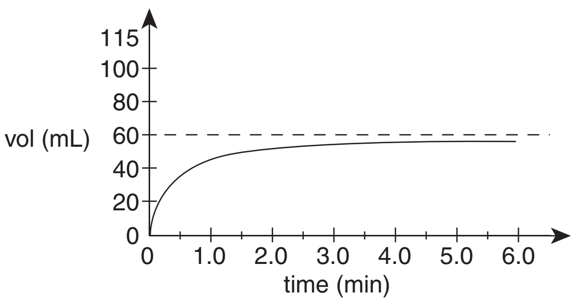
iii. $M(MCO_3) = \frac{m}{n} = \frac{0.469}{4.69 \times 10^{-3}} = 100\ \text{g mol}^{-1}$ 1 mark

c. $M(MCO_3) = M(M) + 12.0 + 16.0 \times 3 = 100\ \text{g mol}^{-1}$

$\therefore M(M) = 40\ \text{g mol}^{-1}$

$\therefore$ M is Ca 1 mark

d.

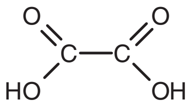


2 marks

Total 7 marks

Question 3

a.



1 mark

b. $C_2HO_4^-(aq) + H_2O(l) \rightleftharpoons C_2O_4^{2-}(aq) + H_3O^+(aq)$

$$K_{a2} = \frac{[C_2O_4^{2-}][H_3O^+]}{[C_2HO_4^-]}$$

1 mark

c. **i.**

$C_2H_2O_4$	H_3O^+	$C_2HO_4^-$

⟶ decreasing concentration

1 mark

ii. The weak acid $C_2H_2O_4$ only partially ionises, hence $[C_2HO_4^-] < [C_2H_2O_4]$. 1 mark

With the first ionisation $[C_2HO_4^-] = [H_3O^+]$. With the second ionisation (which only occurs to a very small extent) some $C_2HO_4^-$ ions react to produce more H_3O^+ ions, hence $[C_2HO_4^-] < [H_3O^+]$. 1 mark

d. Any two of

- known formula;
- obtainable in pure form;
- does not deteriorate or react with the atmosphere;
- preferably high molar mass;
- preferably inexpensive.

2 × 1 = 2 marks
Total 7 marks

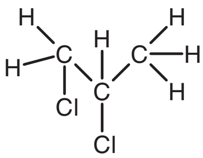
Question 4

a. Crude oil is heated to very high temperatures. Vapours rise up a cooling tower and fractions condense at various points in the tower as their boiling temperature is reached. 1 mark

Fractions collected contain hydrocarbons with similar boiling points. The lightest hydrocarbons collect at the lowest temperature. 1 mark

b. $C_8H_{18}(g) \rightleftharpoons C_3H_6(g) + C_5H_{12}(g)$ 1 mark

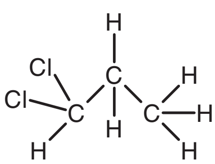
c. **i.**



1 mark

ii. 1,2-dichloropropane 1 mark

iii.



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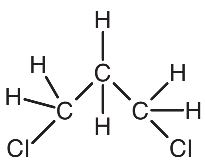

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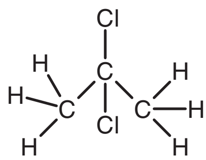

1 mark

iv. 1,1-dichloropropane, 1,3-dichloropropane, 2,2-dichloropropane 1 mark

v. The Cl_2 adds across the double bond so that the two chlorine atoms must be on different, but adjacent, carbon atoms. 1 mark

Total 8 marks

Question 5

a.

	$2SO_2$	O_2	$2SO_3$
n(initial)	1.00	1.00	–
change	–0.828	–0.414	+0.828
n(equilibrium)	0.172	0.586	0.828
concentration at equilibrium	0.172	0.586	0.828

2 marks

$K = \frac{[SO_3]^2}{[O_2][SO_2]^2} = \frac{(0.828)^2}{(0.586)(0.172)^2} = 39.5\ M^{-1}$ 1 mark

b. lowered 1 mark

The reaction is exothermic. Lowering the temperature will favour the temperature raising forward reaction. 1 mark

c. **i.** 2 *(The oxidation number of S changes from +6 to +4.)* 1 mark

ii. 1 *(acid and metal oxide)* 1 mark

iii. 1 or 3 or 4 or 5 *(The oxidation number of S is +6 throughout.)* 1 mark

Total 8 marks

Question 6

a. $CH_3CH_2OH(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 4e$ 1 mark

b. **i.** $n(KMnO_4) = c \times V = 0.0915 \times 22.34 \times 10^{-3} = 2.04 \times 10^{-3}$ mol 1 mark

ii. $n(CH_3CH_2OH) = \frac{5}{4} \times n(KMnO_4) = \frac{5}{4} \times 2.04 \times 10^{-3}$ 1 mark

$n(CH_3CH_2OH)_{\text{in 10.00 mL of wine}} = n(CH_3CH_2OH)_{\text{diluted}} \times \frac{200.0}{25.00} = 0.0204$ mol 1 mark

iii. $m(CH_3CH_2OH) = n \times M = 0.0204 \times 46.0 = 0.940$ g 1 mark

$V(CH_3CH_2OH) = \frac{m}{d} = \frac{0.940}{0.785} = 1.20$ mL 1 mark

$\%v/v = \frac{V(CH_3CH_2OH)}{V(\text{wine})} \times \frac{100}{1} = \frac{1.20}{10.0} \times \frac{100}{1} = 12.0\%$ 1 mark

c. burette 1 mark

Water dilutes the $KMnO_4$ in the burette, hence more is needed for the titration. This increased volume leads to an increase in the calculated ethanol content. 1 mark

(Standard flasks are always rinsed with water. Water in the pipette would dilute the wine, leading to a lower % v/v.)

d. **i.** A series of compounds where successive members differ by CH_2. 1 mark

ii. Boiling points increase as size increases. This is due to increasing strength of dispersion forces as the molecular size increases. 1 mark

Total 11 marks