



THE SCHOOL FOR EXCELLENCE
UNIT 3 CHEMISTRY 2007
COMPLIMENTARY WRITTEN EXAMINATION 1

SECTION A – MULTIPLE CHOICE QUESTIONS

- | | |
|---------|---|
| Item 1 | Answer is C |
| Item 2 | Answer is B |
| Item 3 | Answer is C |
| Item 4 | Answer is B |
| Item 5 | Answer is A |
| Item 6 | Answer is A |
| Item 7 | Answer is D |
| Item 8 | Answer is C |
| Item 9 | Answer is A |
| Item 10 | Answer is B |
| Item 11 | Answer is D |
| Item 12 | Answer is C (Components adsorb - not absorb). |
| Item 13 | Answer is B |
| Item 14 | Answer is D |
| Item 15 | Answer is A |
| Item 16 | Answer is C |
| Item 17 | Answer is B |
| Item 18 | Answer is D |
| Item 19 | Answer is A |
| Item 20 | Answer is C |

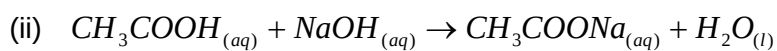
SECTION B – SHORT ANSWER QUESTIONS

QUESTION 1



$$n(\text{NaOH}) = n(\text{HCl}) = cV = 1.00 \times 0.0333 = 0.0333 \text{ mol}$$

1 mark

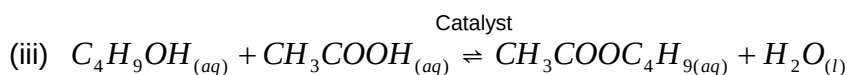


$$n(\text{CH}_3\text{COOH})_{\text{reacting}} = n(\text{NaOH})_{\text{reacting}}$$

$$= n(\text{NaOH})_{\text{initially added}} - n(\text{NaOH})_{\text{in equation 3}}$$

$$= (1.00 \times 0.050) - (0.0333) = 0.0167 \text{ mol}$$

2 marks



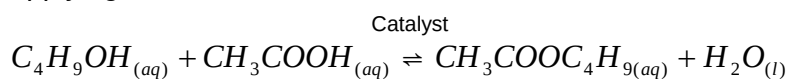
$$n(\text{butanol}) = n(\text{CH}_3\text{COOH})_{\text{reacting in equation 1}}$$

$$= n(\text{CH}_3\text{COOH})_{\text{initially added}} - n(\text{CH}_3\text{COOH})_{\text{in equation 2}}$$

$$= 0.05 - 0.0167 = 0.0333 \text{ mol}$$

2 marks

(iv) Applying mole ratios:



$$1 \text{ mole} \quad + 1 \text{ mole} \quad \rightarrow 1 \text{ mol}$$

$$0.0333 \text{ mole} + 0.0333 \text{ mole} \quad \rightarrow 0.0333 \text{ mol}$$

	$\text{C}_4\text{H}_9\text{OH}_{(aq)}$	$\text{CH}_3\text{COOH}_{(aq)}$	$\text{CH}_3\text{COOC}_4\text{H}_9_{(aq)}$
Initial Mole	0.0500	0.0500	0
Final Mole	$0.0500 - 0.0333 = 0.0167$	$0.0500 - 0.0333 = 0.0167$	$0 + 0.0333 = 0.0333$

2 marks

b. (i)
$$K = \frac{[CH_3COOC_4H_9(aq)][H_2O(l)]}{[C_4H_9OH(aq)][CH_3COOH(aq)]} = \frac{[CH_3COOC_4H_9(aq)]}{[C_4H_9OH(aq)][CH_3COOH(aq)]} M^{-1}$$

1 mark

(ii) As $V = 1 \text{ dm}^3$, $C = n$.

	$C_4H_9OH_{(aq)}$	$CH_3COOH_{(aq)}$	$CH_3COOC_4H_9(aq)$
Initial Mole	0.0500	0.0500	0
Final Mole	$0.0500 - 0.0333 = 0.0167$	$0.0500 - 0.0333 = 0.0167$	$0 + 0.0333 = 0.0333$
Eq Conc	0.0167 M	0.0167 M	0.0333 M

$$K = \frac{0.0333}{(0.0167)^2} = 119.4019 = 119 \text{ M}^{-1}$$

1 mark

- c. (i) Heating to 110°C will evaporate water but not the organic molecules involved in the reaction. The system will oppose this change by favouring the forward reaction. Hence the yield of ester will increase.

2 marks

- (ii) The catalyst used in this process is usually concentrated sulphuric acid as it is a strong dehydrating agent (reaction requires the removal of water).

1 mark

- (iii) Due to structural arrangement, esters cannot form hydrogen bonds with water - which decreases their solubility.

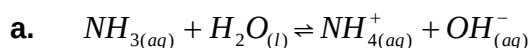
Both alcohols and carboxylic acids display exposed polar covalent bonds that can form hydrogen bonds with water, and hence are soluble to some extent in water.

2 marks

- d. The given molecules cannot be used to produce a polyester. Polyesters are produced from the reaction of an alcohol that has two $-OH$ functional groups with a carboxylic acid that has two $-COOH$ functional groups. The given structures do not possess the functional groups for the polymerisation process to occur.

2 marks

QUESTION 2



$$K_b = \frac{[NH_{4(aq)}^+][OH_{(aq)}^-]}{[NH_{3(aq)}]} = 1.79 \times 10^{-5} M$$

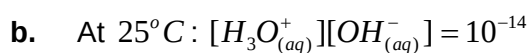
Assume that: $[NH_{4(aq)}^+] = [OH_{(aq)}^-]$

$$[NH_{3(aq)}]_{eq} = [NH_{3(aq)}]_{initial} = 0.100 M$$

$$K_b = \frac{[OH_{(aq)}^-]^2}{[NH_{3(aq)}]} = \frac{[OH_{(aq)}^-]^2}{0.100} = 1.79 \times 10^{-5} M$$

$$[OH_{(aq)}^-] = \sqrt{1.79 \times 10^{-5} \times 0.100} = 1.3379 \times 10^{-3} M = 1.34 \times 10^{-3} M$$

3 marks



$$[H_3O_{(aq)}^+] = \frac{10^{-14}}{[OH_{(aq)}^-]} = \frac{10^{-14}}{1.3379 \times 10^{-3}} = 7.4744 \times 10^{-12} M$$

$$pH = -\log_{10}[H_3O_{(aq)}^+] = -\log_{10}(7.4744 \times 10^{-12}) = -(-11.126) = 11.1$$

2 marks

- c. A small value of K indicates that the position of equilibrium lies to the left. This indicates that $OH_{(aq)}^-$ is the stronger base.

2 marks

QUESTION 3

- a. (i) Curve A.

The greater concentration of hydrochloric acid gives rise to an increased frequency in collisions, hence the reaction rate increases.

1 mark

- (ii) As Mg is the limiting reactant and it determines how much hydrogen gas is produced. **Note:** This is not an equilibrium application.

1 mark

- b. The increased amount of magnesium provides a greater surface area for reaction. Therefore, the number of successful collisions increases and hence the reaction rate increases.

Note: The increase in mass of magnesium has no effect on the concentration of reactants in solution (magnesium is a solid).

1 mark

- c. Curve A.

As the reaction proceeds, the concentration of HCl remaining per unit time is higher in the greater volume. (Note: Initial reaction rates are equal).

The greater concentration of hydrochloric acid gives rise to an increased frequency in collisions, hence the reaction rate increases.

2 marks

QUESTION 4

- a. To reduce SO_2 emissions when fuels are burned.

OR

Sulfur acts as a catalytic poison, impeding or destroying the catalytic activity of many catalysts that are used in the refinery.

1 mark

- b. (i) The rising vapour percolates through the hydrocarbon liquid that has condensed on each horizontal tray in the fractionating tower. The components of the vapour whose boiling point is lower than that of the condensed fraction will condense, allowing for the separation of hydrocarbons in accordance to their chain length (and hence boiling point).

2 marks

- (ii) Thermal cracking.

1 mark

- (iii) Unsaturated hydrocarbons are produced due to insufficient quantities of hydrogen gas being available.

1 mark

- c. (i) Vanadium (V) oxide (V_2O_5).

1 mark



1 mark

- (iii) This strategy is known as double absorption and serves two purposes:

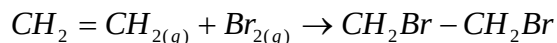
It increases the yield of oleum ($H_2S_2O_{7(l)}$).

It decreases the emissions of $SO_{2(g)}$ into the atmosphere.

1 mark

QUESTION 5

- a. (i) The double bonds in unsaturated hydrocarbon molecules are broken and two atoms of bromine are added to the hydrocarbon via an addition reaction. In the process, the concentration of bromine decreases.



Brown Colourless

2 marks

- (ii) UV light.

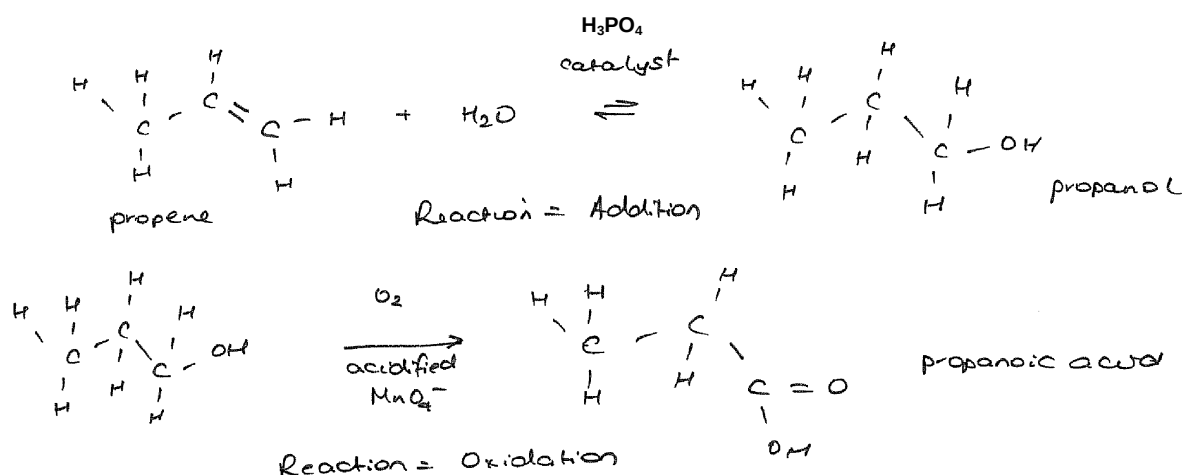
1 mark

- b. Difference in reactivity: Due to the presence of the double bonds in alkenes.

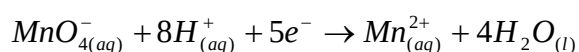
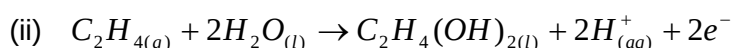
Similarity in physical properties: Due to similar chain length, composition and polarity.

2 marks

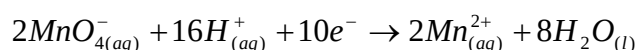
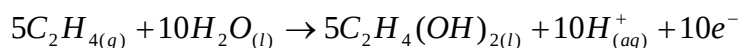
- c. (i)



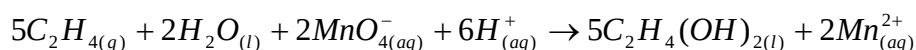
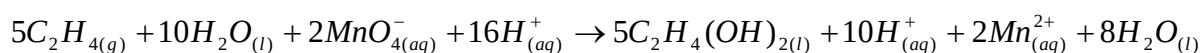
3 marks



Balance for electrons:



Overall:



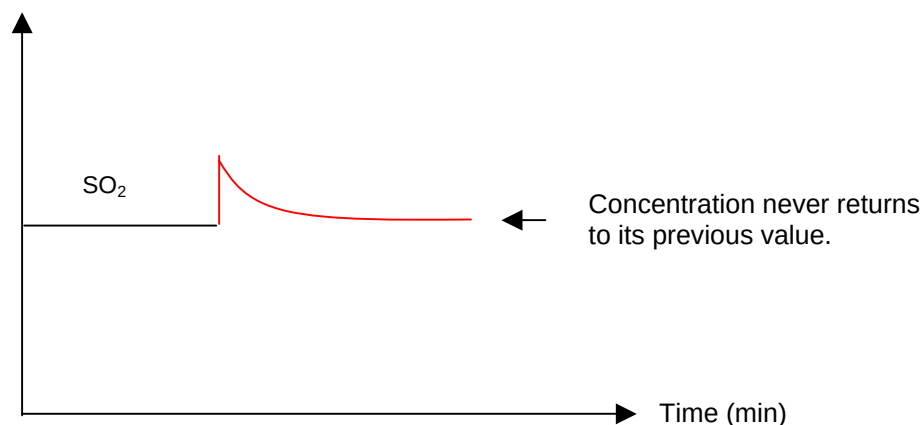
3 marks

QUESTION 6

- a. (i) The key word in this question is mass (not concentration).

When the volume of the container is decreased, the concentration of $\text{SO}_{2(g)}$ increases. The system opposes the introduced change by favouring the reaction that will decrease the number of gas particles. A net forward reaction occurs. $\text{SO}_{2(g)}$ is consumed, and hence the amount **decreases**.

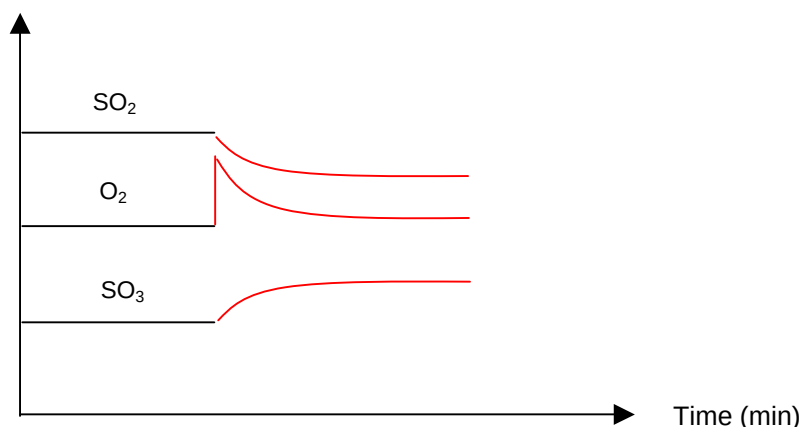
Concentration (M)



1 mark

- (ii) Adding oxygen will increase the concentration of this reactant immediately. The system opposes the introduced change by favouring the reaction that will decrease reactant concentrations. A net forward reaction occurs. $\text{SO}_{2(g)}$ is consumed, and hence the amount **decreases**. (**Note:** In this case, the new $\text{SO}_{2(g)}$ concentration will be lower than the previous equilibrium mixture).

Concentration (M)



1 mark

- (iii) As temperature is being kept constant, the equilibrium constant does not change. Hence there is no change to the extent of the reaction.

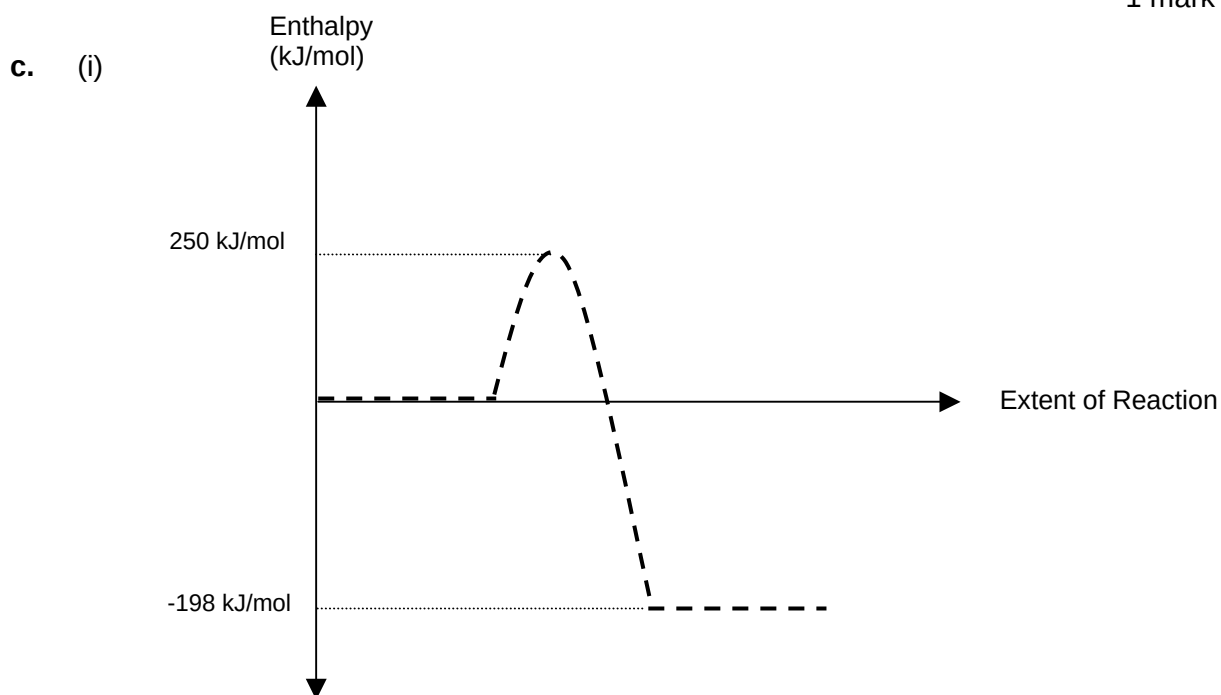
1 mark

- b. (i) When a reactant is added to the equilibrium mixture, a forward reaction is favoured. As the forward reaction is exothermic, heat will be released as the system re-establishes equilibrium. i.e. the temperature will rise.

1 mark

- (ii) When product is removed, a net forward reaction is favoured. Reactants are consumed, hence their concentrations decrease. The probability of an effective collision will therefore also decrease, resulting in fewer collisions. The rate of the forward reaction therefore decreases as the system re-establishes equilibrium.

1 mark



3 marks

- (ii) $E_A = H_{final} - H_{initial} = 250 - -198 = 448 \text{ kJ / mol}$

Note: You cannot calculate the activation energy for the forward reaction and then change the sign (activation energies are always positive). Redraw the enthalpy curve interchanging reactants and products, and then calculate the activation energy barrier.

1 mark

- (iii) The given ΔH value applies for the mole ratios in the given equation i.e. 2 mole of sulphur dioxide. ΔH for the reaction involving 1 mole of sulphur dioxide will therefore be half the given value i.e. $\Delta H = -99 \text{ kJ}$

1 mark

QUESTION 7

- a. (i) State 2 of the following: Monochromator.
Atomiser.
Detector.

1 mark

- (ii) The atomiser converts metal ions to metal atoms which are able to absorb radiation.

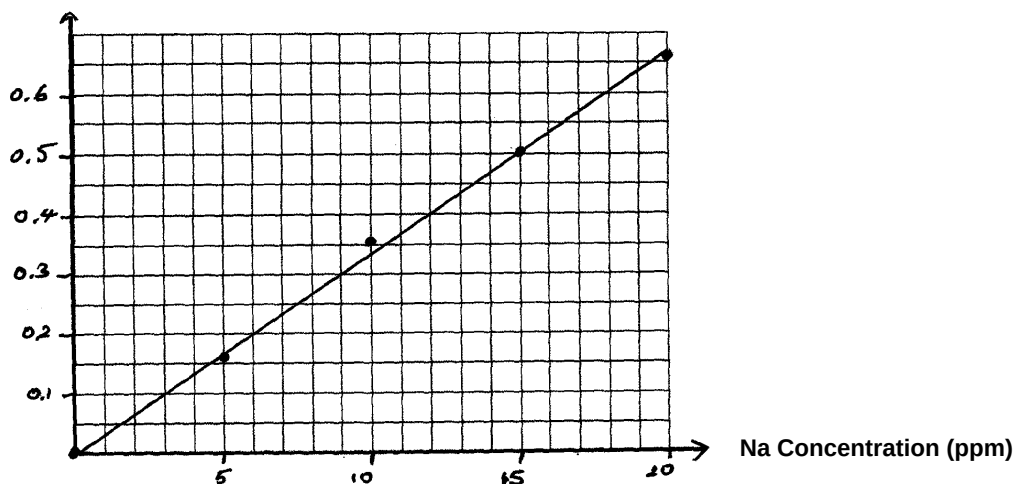
The monochromator filters out unwanted wavelengths produced during the procedure so that the detector only picks up the selected radiation.

The detector is able to determine the degree of absorption of specific radiation by metal atoms by measuring the amount of transmitted light.

1 mark

- b. (i) The line of best fit must be drawn through the labelled points.

Absorbance (Units)



2 marks

- (ii) The concentration in *ppm* of sodium in the diluted sample is approximately 12.5 *ppm*.

The peach filtrate was diluted 10 fold before its absorbance was measured in the AAS. Therefore, the concentration of sodium in the undiluted sample is 10 times that in the diluted sample.

i.e. 125 *ppm*

1 mark

- c. (i) The concentration of the undiluted peach filtrate ($25.00\text{ ml} = 25.00\text{ g}$ assuming that the density is 1 g/ml) is 125 ppm .

$125\text{ ppm} = 125\text{ g}$ of sodium in $1 \times 10^6\text{ g}$ of filtrate.

Mass (g) of sodium in 25.00 ml or 25.00 g filtrate is $125 \times \frac{25.00}{10^6} = 3.125 \times 10^{-3}\text{ g}$

As it is assumed that all of the sodium in the peaches is released into the filtrate, the mass of sodium in the 50.00 g sample of the peaches is also $3.125 \times 10^{-3}\text{ g}$.

i.e.

$3.125 \times 10^{-3}\text{ g}$ sodium / 50.00 g peaches

$2 \times 3.125 \times 10^{-3}\text{ g}$ sodium / 100.00 g peaches

$6.25 \times 10^{-3}\text{ g}$ sodium / 100.00 g peaches

6.25 mg sodium per 100.00 g peaches.

$$\% = \frac{6.25}{5.00} \times 100 = 125\%$$

i.e. The true sodium concentration is 25.0% higher than the stated claim.

3 marks

- (ii) Mass of sodium in 100.00 g of peaches is 6.25 mg .

$$n(\text{Na}) = \frac{m}{M} = \frac{6.25 \times 10^{-3}}{23} = 2.7174 \times 10^{-4}\text{ mol}$$

$$n(\text{NaCl}) = n(\text{Na}^+) = n(\text{Na}) = 2.7174 \times 10^{-4}\text{ mol}$$

$$m(\text{NaCl}) = n \times M = 2.7174 \times 10^{-4} \times 58.5 = 0.015897 = 0.0159\text{ g}$$

3 marks

- d. (i) The light source (or wavelength or frequency) would need to be changed to a lead source.

1 mark

- (ii) A new calibration curve would need to be constructed using solutions of known lead concentrations.

1 mark