Neap

Trial Examination 2021

Suggested solutions

QCE Chemistry Units 3&4

Paper 2

SECTION 1

QUESTION 1 (7 marks)

a) 1-propyl butanoate *[1 mark]*

b) $\text{atom economy} = \frac{M(\text{desired product})}{M(\text{reactants})} \times 100 = \frac{130.0}{88.0 + 60.0} \times 100$ *[1 mark]*

$= 87.8\%$ *[1 mark]*

c) $n(CH_3CH_2CH_2COOH) = \frac{m}{M} = \frac{4.50}{88.0}$ mol *[1 mark]*

$n(CH_3CH_2CH_2COOCH_2CH_2CH_3) = n(CH_3CH_2CH_2COOH) = \frac{4.50}{88.0}$ mol *[1 mark]*

$m(CH_3CH_2CH_2COOCH_2CH_2CH_3) = n \times M = \frac{4.50}{88.0} \times 130 = 6.6477$ g *[1 mark]*

$\%\ \text{yield} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100 = \frac{5.32}{6.6477} \times 100 = 80.0\%$ *[1 mark]*

QUESTION 2 (7 marks)

a) i) triglyceride *[1 mark]*

ii) $C_3H_8O_3$ *(glycerol)* *[1 mark]*

iii) Compound C ($C_{17}H_{29}COOH$) *[1 mark]*

(Compound E ($C_{19}H_{39}$) is a saturated fatty acid chain; formula C_nH_{2n+1}
Compound D ($C_{15}H_{29}$) is a monounsaturated fatty acid chain; formula C_nH_{2n-1}
Compound C ($C_{17}H_{29}$) is a polyunsaturated fatty acid chain; formula C_nH_{2n-5})

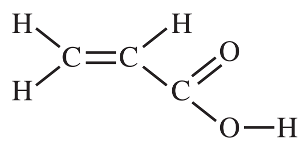
b) i) Biodiesel is a largely non-polar molecule, with the majority of the molecule being a non-polar hydrocarbon chain. *(A small section with polarity occurs around the ester group.)* *[1 mark]*
Non-polar molecules do not interact with polar water molecules to allow solubility, and so biodiesel is not soluble in the aqueous layer. *(The small area of polarity around the ester does not produce a soluble molecule.)* *[1 mark]*

ii) Methanol, CH_3OH, is a small polar molecule, with partial negative and positive charges on the O atom and H atom respectively. *[1 mark]*

The polar methanol molecules form hydrogen bonds with water molecules, allowing the methanol to dissolve in the water. *[1 mark]*

QUESTION 3 (8 marks)

a)



[1 mark]

b) Acrylic acid ionises according to the following equation:

$CH_2CHCO_2H(l) + H_2O(l) \rightleftharpoons CH_2CHCO_2^-(aq) + H_3O^+(aq)$ *[1 mark]*

At equilibrium: $[CH_2CHCO_2^-] = [H_3O^+]$

$[CH_2CHCO_2H]$ is assumed to be approximately equal to 0.10 M because for a weak acid the extent of ionisation is very small. *[1 mark]*

$$K_a = \frac{[H_3O^+]\times[CH_2CHCO_2^-]}{[CH_2CHCO_2H]}$$ *[1 mark]*

$$= \frac{[H_3O^+]^2}{0.10} = 5.6\times10^{-5}$$ *[1 mark]*

$[H_3O^+] = 0.002366$ M

$pH = -\log[H_3O^+] = -\log(0.002366) = 2.6$ *[1 mark]*

c) The addition of water will dilute the acid solution; the $[H_3O^+]$ will decrease and so the pH will increase. *[1 mark]*

Adding water, a reactant in the acrylic acid equilibrium reaction, will shift the equilibrium to the right to partially overcome the addition of H_2O, increasing the $[H_3O^+]$. However, the effect of the dilution is greater than the effect of the shift, and so overall the $[H_3O^+]$ will decrease and pH will increase. *[1 mark]*

QUESTION 4 (10 marks)

a) i) aldose *(contains the CHO aldehyde group)* *[1 mark]*

ii) Amylose is a linear, straight chain polymer. *[1 mark]*

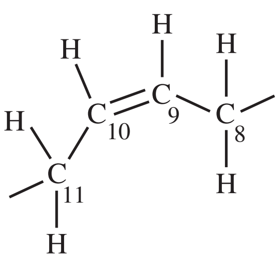
It is composed of glucose molecules joined by glycosidic links at carbons 1 and 4 of the glucose molecules. *[1 mark]*

Amylopectin is a branched polymer. *[1 mark]*

It is composed of glucose molecules joined by glycosidic links of both the 1–4 and 1–6 types *(the 1–6 links occur every 24–30 glucose units).* *[1 mark]*

b) i) *trans (the alkyl groups are across/on opposite sides of the double bond)* *[1 mark]*

ii)



[1 mark]

c) Shake each fatty acid sample with bromine water. *[1 mark]*

$C_{17}H_{35}COOH$, a saturated fatty acid, will show no reaction. *[1 mark]*

$C_{17}H_{33}COOH$, an unsaturated fatty acid with one C=C bond, will react to decolourise the bromine. *[1 mark]*

QUESTION 5 (8 marks)

a) *For example:*

Ethanoic acid is acidic and will react with sodium hydrogen carbonate to evolve carbon dioxide. *[1 mark]*

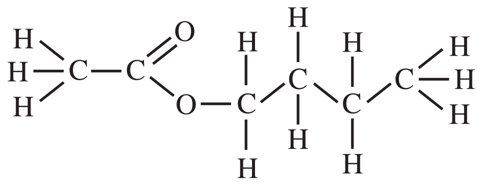
Butan-1-ol is not acidic and will show no reaction with sodium hydrogen carbonate. *[1 mark]*

OR

Ethanoic acid is acidic and will produce aqueous solutions with pH less than 7. *[1 mark]*

Butan-1-ol is not acidic and will produce aqueous solutions with pH equal to 7. *[1 mark]*

b)



[1 mark]

c) Butyl ethanoate is the larger molecule and so will have stronger dispersion forces between molecules. This would be expected to result in a higher boiling point compared with that of butan-1-ol. Butyl ethanoate also shows some polarity at the ester link, and so has dipole–dipole bonding between molecules. *[1 mark]*

Butan-1-ol is a polar molecule containing a hydroxyl group that can form hydrogen bonds. This much stronger intermolecular bonding results in an increased boiling point. *[1 mark]*

The net effect of the different sizes and bonding types is that the two compounds have similar boiling points. *[1 mark]*

d) Ethanoic acid and butan-1-ol both contain the hydroxyl functional group. These groups produce strong broad signals on the infrared spectrum at 2500–3000 cm^{-1} and 3200–3600 cm^{-1} respectively. *[1 mark]*

These signals are not present on the infrared spectrum of the product sample, indicating that the sample is not contaminated with either the acid or the alcohol. *[1 mark]*

QUESTION 6 (8 marks)

a) C_7H_{16} *[1 mark]*

b) In type I, the side groups are randomly distributed on either side of the polymer chain. This prevents the chains from close packing and forming crystalline regions. *[1 mark]*

The regular structure of type II, where all the side groups are on the same side of the polymer chain, means that molecules can align more closely to one another, reducing the intermolecular distances. *[1 mark]*

This close packing leads to crystalline regions with stronger dispersion forces. This stronger bonding results in a higher melting point for the type II polymer. *[1 mark]*

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c) i) *For example:*

Polymer materials are generally biologically inert, chemical and corrosion resistant. *[1 mark]*

These properties produce a durable, long-lasting product. *[1 mark]*

OR

The properties of polymers can be modified – for example, by adding plasticisers or forming foams. *[1 mark]*

These modifications produce an enormous variety of products customised for specific uses. *[1 mark]*

ii) *For example:*

These polymers are sourced from fossil fuels, a non-renewable source. *[1 mark]*

This means that supply will be limited as reserves of fossil fuels diminish. *[1 mark]*

OR

These polymer materials are non-biodegradable. *[1 mark]*

They accumulate in landfill and persist for a long time, presenting an environmental problem. *[1 mark]*

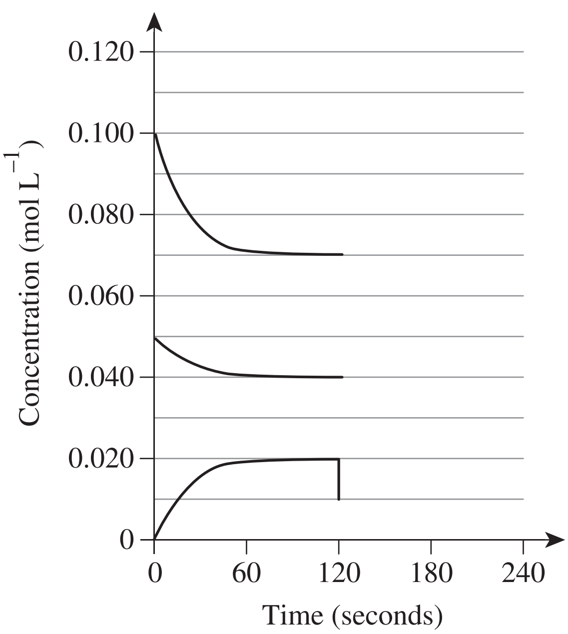
QUESTION 7 (9 marks)

a) i) $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}\ M^{-2}$ *[1 mark]*

ii) $K_c = \frac{(0.020)^2}{(0.040) \times (0.070)^3}$ *[1 mark]*

$= 29\ M^{-2}$ *[1 mark]*

b) i)



[2 marks]
1 mark for concentration decreases.
1 mark for concentration reaches a value of 0.010 M.

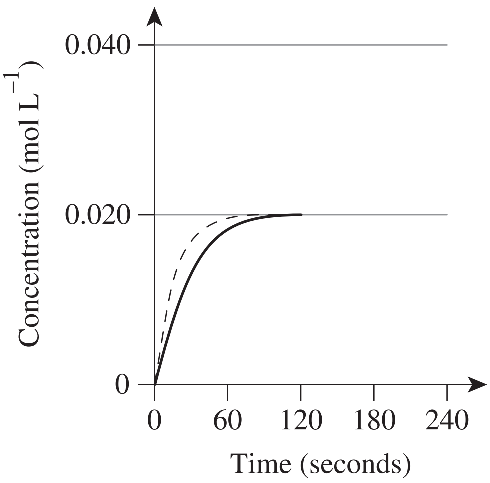
ii)

Shift in equilibrium position		Effect on the value of K_c	
to the product side	☐	increases	☐
to the reactant side	✓	decreases	☐
no change	☐	no change	✓

(Increasing the volume reduces the pressure. The reaction will move to the left to increase the pressure as there are more moles of gas on the reactant side and hence higher pressure. With no change in temperature the value of K_c is unchanged.)

[2 marks]
1 mark for each correct box.

c)



[2 marks]
1 mark for steeper slope.
1 mark for same value reached.
Note: The correct response is indicated by the dashed line.

QUESTION 8 (8 marks)

a) i) $n(\text{NaOH}) = c \times V = 0.102 \times 14.6 \times 10^{-3}$ mol *[1 mark]*

$n(\text{C}_6\text{H}_8\text{O}_7) = \frac{1}{3} n(\text{NaOH})$ *[1 mark]*

$c(\text{C}_6\text{H}_8\text{O}_7) \text{ diluted} = \frac{n}{V} = \frac{1 \times 0.102 \times 14.6 \times 10^{-3}}{3 \times 20.0 \times 10^{-3}}$ mol L^{-1} *[1 mark]*

$c(\text{C}_6\text{H}_8\text{O}_7) \text{ undiluted} = \frac{n}{V} = \frac{1 \times 0.102 \times 14.6 \times 10^{-3}}{3 \times 20.0 \times 10^{-3}} \times \frac{20.0}{2.00} = 0.2482$ mol L^{-1} *[1 mark]*

$m(\text{C}_6\text{H}_8\text{O}_7) = n \times M = 0.2482 \times 192 = 47.7$ g present in 1000 mL

4.77 g in 100 mL = 4.77 % m/v *[1 mark]* ii)

The calculated level of citric acid would be higher than the true value.	✓
The calculated level of citric acid would be lower than the true value.	
There would be no effect on the calculated level of citric acid.	

[1 mark]

(Diluting the NaOH in the burette will lead to a higher titre as more of the less-concentrated solution will be needed to reach the endpoint. A larger titre will give a higher value for the citric acid concentration.)

b) $C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2e^-$ *[1 mark]*

c) The acid–base titration determines the total acid content of the lemon juice. This will include the citric acid and other acids such as vitamin C, and so will always overestimate the citric acid content. *[1 mark]*